

THE BOOK OF FISHES

FISHES, GAME FISHES, AND OTHER
INHABITANTS OF NORTH AMERICAN COASTAL
AND INLAND WATERS

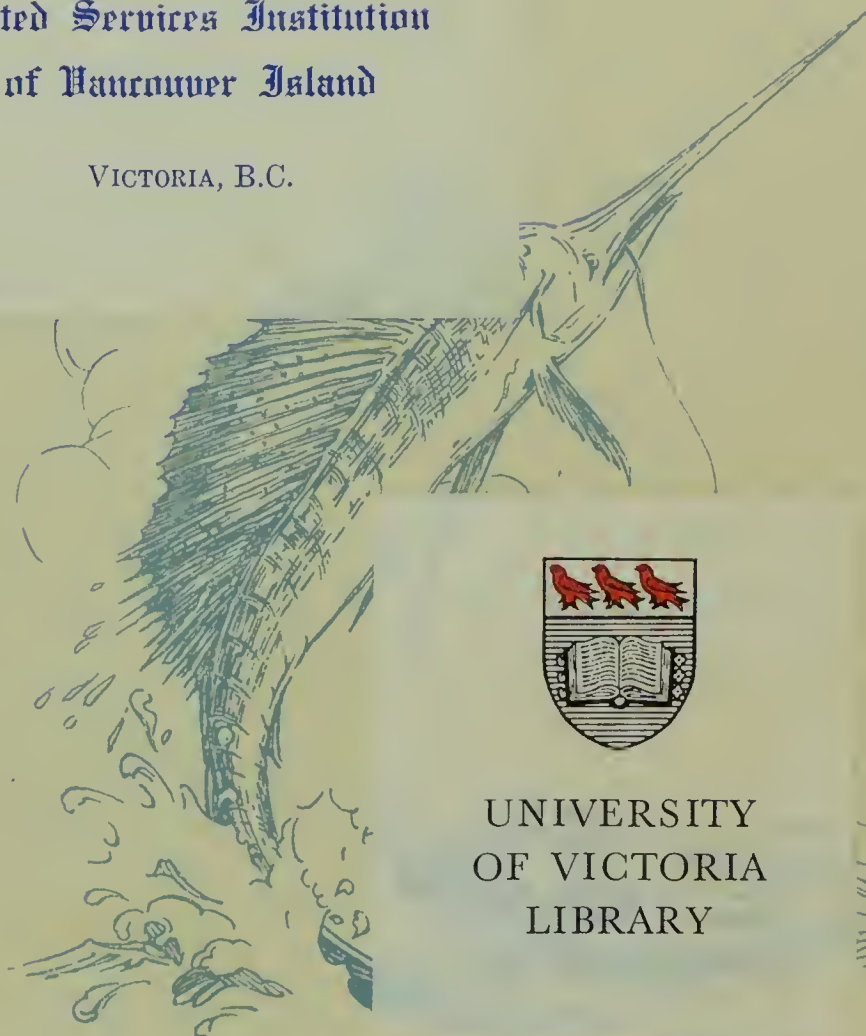




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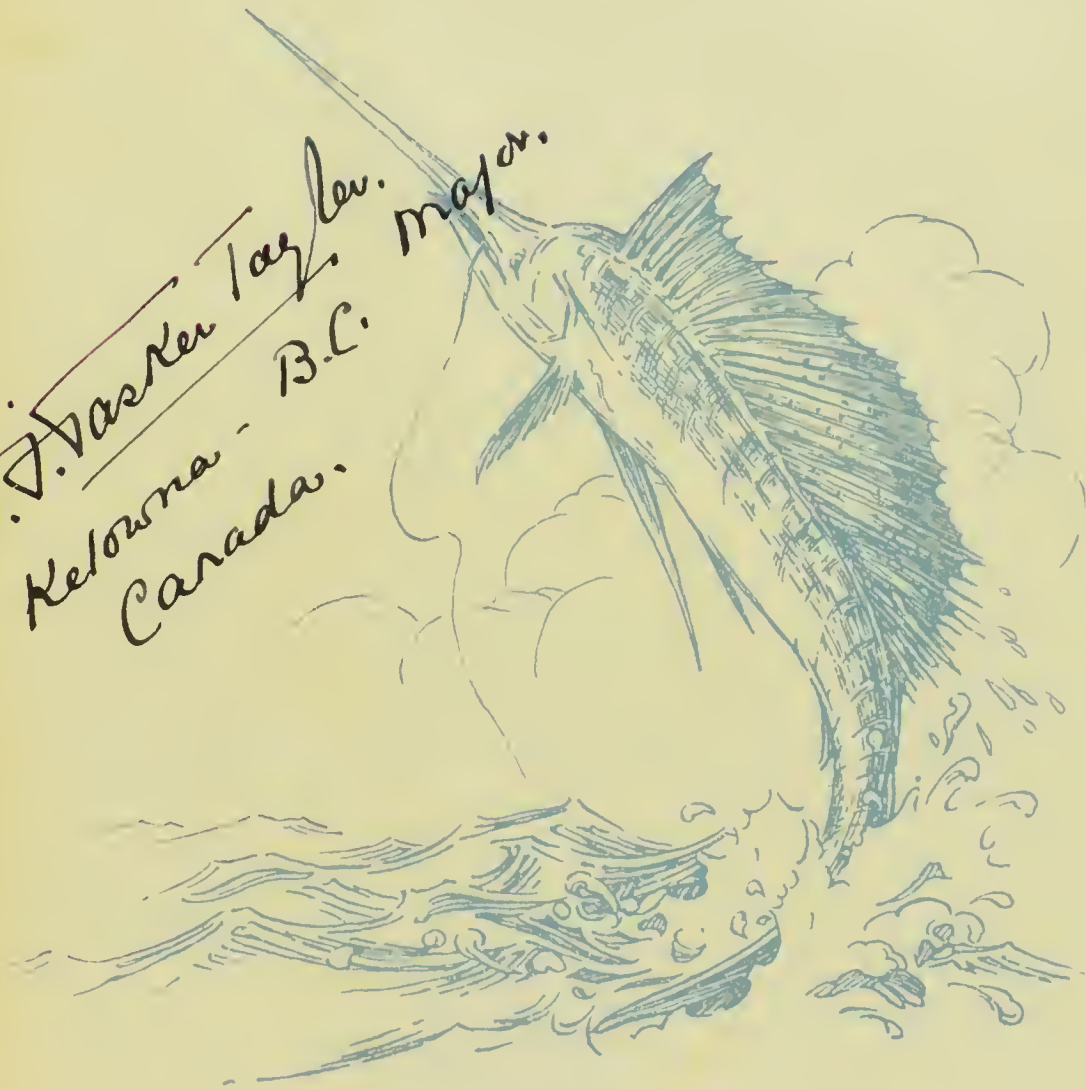
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1 September 1970

THE BOOK OF FISHES

*Revised and Enlarged Edition, Presenting the Better Known
Species of Food and Game Fishes of the Coastal and
Inland Waters of the United States*

EDITED BY

JOHN OLIVER LA GORCE, Litt.D., D.Sc.

Vice President, National Geographic Society

With 443 Color Portraits, 102 Biographies,
and 162 Photographs

Narrative by John Oliver La Gorce; Charles Haskins Townsend, *Former Director, New York Aquarium*; John T. Nichols, *Curator of Recent Fishes, American Museum of Natural History*; Louis L. Mowbray, *Curator, Bermuda Government Aquarium*; Leonard P. Schultz, *Curator of Fishes, United States National Museum*; Roy Waldo Miner, *Curator of Marine Life, American Museum of Natural History*; Van Campen Heilner, *Associate, Dept. of Ichthyology, American Museum of Natural History*; Russell Maloney, Imogene Powell. Original paintings by Hashime Murayama and Else Bostelmann.



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Table of Contents

	Page
Foreword	
Fishes and Fisheries of Our Eastern Seaboard—By John Oliver La Gorce The Atlantic Annually Yields Incalculable Wealth in Seafood and Biological Puzzles for Scientists.	9
Our Heritage of the Fresh Waters—By Charles Haskins Townsend In Fishery Resources of Rivers and Lakes the United States Leads the World.	95
Some Curious Inhabitants of the Gulf Stream—By John T. Nichols Along Shores Bathed by Tropical Currents Feed Schools of Bright-hued Fishes.	147
Devilfishing in the Gulf Stream—By John Oliver La Gorce Five Hours of Battle with a Giant Ray off the East Coast of Florida.	169
Certain Citizens of the Warm Seas—By Louis L. Mowbray In the Struggle for Existence, Fishes Fight Wars Continuous and Everlasting.	179
Treasures of the Pacific—By Leonard P. Schultz Marine Fishes and Fisheries Yield Vast Wealth from Alaska to Baja California.	219
Fishing in Pacific Coast Streams—By Leonard P. Schultz Hatcheries, Stream Improvement, and Fish Ladders Assure the Future of Sporty Trouts and Highly Valued Salmon.	263
Sea Creatures of Our Atlantic Shores—By Roy Waldo Miner Crabs, Lobsters, Oysters, Mussels, Snails, Sponges, Jellyfishes, Starfishes, Sea Worms, and Other Strange Marine Life from Maine to Mexico.	295
The Lordly Tarpon—By Van Campen Heilner Among Islands and Passes of Our South Atlantic Shores, the Mighty “Silver King” Offers Battle.	327
Market Fish Have Many Names—By Russell Maloney Between the Fisherman’s Net and the Customer’s Table Appear Many Finny Aliases and Doubles.	337
“Compleat Angler” Fishes for Fossils—By Imogene Powell In Wyoming’s Rocky Mountains Inhabitants of Ancient Seas Are “Caught” with Hammer and Chisel.	349

Species Portrayed in the Color Plates (Concluded)

NAME	PAGE	NAME	PAGE
Ornate Worm	320	Shad (<i>Alosa sapidissima</i>)	56
Pacific Cultus (<i>Ophiodon elongatus</i>)	236	Shark Sucker (<i>Echeneis naucrates</i>)	158
Pacific Mackerel (<i>Pneumatophorus diego</i>)	225	Sheep Crab (<i>Loxorhynchus grandis</i>)	251
Pelagia	311	Sheepshead (<i>Archosargus probatocephalus</i>)	90
Phrygian Sea Star	319	Silver Salmon (<i>Oncorhynchus kisutch</i>)	284
Pike or Pickerel (<i>Esox lucius</i>)	138	Small-mouth Bass (<i>Micropterus dolomieu</i>)	109
Pilchard (<i>Sardinops caerulea</i>)	245	Smelt (<i>Osmerus mordax</i>)	76
Pink Coralline	318	Snowy Tunicates	322
Pink Salmon (<i>Oncorhynchus gorbuscha</i>)	288	South Fork Golden Trout (<i>Salmo agaua-bo-nita</i>)	269
Pipefish (<i>Syngnathus griseo-lineatus</i>)	254	Spade Fish or White Angel (<i>Chaetodipterus faber</i>)	154
Piute Trout (<i>Salmo seleniris</i>)	269	Spanish Mackerel (<i>Scomberomorus maculatus</i>)	199
Pollock (<i>Pollachius virens</i>)	41	Spindle Egg Shells	312
Pompon Weed	318	Spiny Lobster (<i>Panulirus interruptus</i>)	249
Pork Fish (<i>Anisotremus virginicus</i>)	153	Spiny Tube	316
Portuguese Man-of-War (<i>Physalia arethusa</i>)	156, 310	Sponge Crab	316
Portuguese Man-of-War Fish	310	Spotted Cowry	314
Prawn (<i>Pandalus platyceros</i>)	231	Squid	322
Queen Conch	312	Squirrel Fish or Soldato (<i>Holocentrus ascensionis</i>)	153
Queen Trigger-fish (<i>Balistes vetula</i>)	157	Squirrelfish	313
Rainbow Trout (<i>Salmo gairdnerii</i>)	120, 273	Squirrel Hake (<i>Urophycis chuss</i>)	50
Redbeard Sponge	322, 324	Starry Flounder (<i>Platichthys stellatus</i>)	258
Red Branched Sponge	316	Steelhead Trout	273
Red Grouper (<i>Epinephelus morio</i>)	195	Striped Bass (<i>Roccus saxatilis</i>)	83
Red-plumed Worm	320	Striped Mullet (<i>Mugil cephalus</i>)	90
Red Rockfish (<i>Sebastes rosaceus</i>)	234	Striped or Blue Perch (<i>Taeniotoca lateralis</i>)	229
Red Salmon (<i>Oncorhynchus nerka</i>)	286	Sturgeon (<i>Acipenser sturio</i>)	47
Red Star	319	Sulphur Sponge	324
Rock Barnacles	318	Summer Flounder (<i>Paralichthys dentatus</i>)	43
Rock Bass (<i>Ambloplites rupestris</i>)	114	Sunburst Star	319
Rock Beauty (<i>Holacanthus tricolor</i>)	154	Sun Star	319
Rock Crab (<i>Cancer antennarius</i>)	234, 317	Swallow-tail Protozoa	321
Rock Hind (<i>Epinephelus adscensionis</i>)	158	Swollen Egg Shells	312
Rockweed	318	Swordfish (<i>Xiphias gladius</i>)	74
Rosebud	311	Tarpon (<i>Tarpon atlanticus</i>)	202
Rubberlip Perch (<i>Rhacochilus toxotes</i>)	240	Tautog (<i>Tautoga onitis</i>)	67
Runner (<i>Caranx ruber</i>)	205	Three-spined Stickleback (<i>Gasterosteus aculeatus</i>)	275
Sacramento Perch (<i>Archoplites interruptus</i>)	282	Tilefish (<i>Lopholatilus chamaeleonticeps</i>)	78
Sacramento Pike (<i>Ptychocheilus grandis</i>)	278	Venus's-Girdle	311
Sacramento Sucker (<i>Catostomus occidentalis</i>)	278	White-armed Anemone	319
Sand Builder	321	White Crab	315
Sand Collar Snail	309	White Crappie (<i>Pomoxis annularis</i>)	111
Sauger or Sand Pike (<i>Stizostedion canadense</i>)	135	Whitefish (<i>Coregonus clupeiformis</i>)	116
Scale Worm	320	White Perch (<i>Morone americana</i>)	131
Scup (<i>Stenotomus chrysops</i>)	69	White Sea Bass (<i>Cynoscion nobilis</i>)	245
Sea Anemone	318, 322	White Sturgeon (<i>Acipenser transmontanus</i>)	280
Sea Bass (<i>Centropristes striatus</i>)	85	Whiting (<i>Merluccius bilinearis</i>)	50
Sea Beads	322	Winter Flounder (<i>Pseudopleuronectes americanus</i>)	43
Sea Chrysanthemum	319	Yellow Grunt (<i>Haemulon sciurus</i>)	159
Sea Dianthus	321, 322	Yellow Perch (<i>Perca flavescens</i>)	133
Sea Grape	322	Yellow Pike-Perch, Wall-eyed Pike (<i>Stizostedion vitreum</i>)	135
Sea Horse (<i>Hippocampus</i>)	156	Yellowstone Trout (<i>Salmo lewisi</i>)	275
Sea Peach	318	Yellow Tail (<i>Ocyurus chrysurus</i>)	159
Sea Pork	322	Yellowtail (<i>Seriola dorsalis</i>)	225
Sea Potato	317		
Sea Star	322		
Sea Urchin	313		
Sea Vase	322		
Sea Worms	320, 321		
Sergeant Major or Cow Pilot (<i>Abudefduf saxatilis</i>)	160		

FOREWORD

SINCE the earliest days of the white man's settlement in North America, when the seemingly unlimited supply of food fish taken from the waters of the Grand Banks beckoned French fishermen-explorers to American shores and the courageous Pilgrims at isolated Plymouth planted fish as fertilizer with their seed to encourage sufficient crops from Mother Earth to keep alive the struggling colony of homeseekers, the products of the waters of the United States have become increasingly important to the growing Nation.

These same fresh and salt water areas, in addition to being reservoirs of food, provide unending recreational opportunity and healthful out-of-door sport to people in every walk of life, young and old. The thrill of search and contest between man and fighting fish, be it angled for with bent pin or giant hook of steel, has few equals.

The Book of Fishes, it is hoped, will be of interest and value to expert fisherman and layman alike because it presents an illuminating life story of the more important of the fishes to be found in North American waters. These species not only are a vital factor in the Nation's food supply, but also, through the sport and commercial fisheries they support, provide employment for many thousands of men and women.

So rich are American coastal waters, rivers, and bays in variety of fishes that to describe comprehensively every known species would necessitate a dozen encyclopedic volumes, too costly for general ownership. Therefore, out of the great treasure of ichthyological material gathered by the National Geographic Society, the chapters, photographic illustrations, and original color plates of this volume have been selected, and the most famous fishes of the diverse regions of the country, of the East and West coasts and the inland waters between them, are described and pictured.

The paintings from life of 131 species of fishes, especially, offer means of easy identification of the fisherman's catch. These, together with the paintings of 100 other species of marine life, the 162 action photographs, the informative biographies and life histories, derived from extensive scientific and practical study, compose a book which will prove, it is believed, a welcome addition to your natural history library.

The editor desires to acknowledge with appreciation the valued coöperation of Dr. Samuel F. Hildebrand, Senior Ichthyologist of the U. S. Bureau of Fisheries, Dr. Leonard P. Schultz, Curator of Fishes, U. S. National Museum, and others.

JOHN OLIVER LA GORCE

Washington, D. C., 1939.



Photograph by Cy La Tour and Son

JERSEY SURF YIELDS AN ANSWER TO A FISHERMAN'S PRAYER

*"Lord, grant that I may catch a fish so big that even I,
In telling of it afterward, shall have no need to lie."*

FISHES AND FISHERIES OF OUR EASTERN SEABOARD

The Atlantic Annually Yields Incalculable Wealth in Seafood and Biological Puzzles for Scientists

BY JOHN OLIVER LA GORCE

Vice President, National Geographic Society

FOR comparison let us imagine a race living somewhere on tablelands towering into the stratosphere and possessing ships lighter than swan's-down. Imagine them launching out on the surface of the oceans of air, with clouds forever shutting out a view of the distant earth.

Now and then one of their exploring craft might drop a dredge into the unknown. The sounding tube, reaching the earth perchance, might sink into the soil of a cornfield or the mud of a river bank.

The dredge net might capture a bumble-bee or a butterfly. It might conceivably suck in a field mouse or a pine cone. But, whatever it got, how little that would be compared with the vast number of things that would escape its sightless groping!

And so it is with our knowledge of the sea and the vast numbers of creatures that inhabit its depths! Even on the floor of the deepest trench in the abysmal region of the sea's bottom, where no ray of light ever reaches, where Stygian darkness is perpetual, where temperatures ever are all but freezing, and where inconceivable pressures prevail, the miracle of life still goes on.

LIFE UNDER CRUSHING PRESSURE

In some ocean depths the pressure exerted would be equal to that of a block of limestone three feet square and six feet high resting on a square inch of surface. A creature five feet long with an average girth of four feet would have to sustain a pressure of some 20,000 tons.

In size the denizens of the deep seas range from microscopic to mammoth. Occasionally huge hulks of flesh of a tough, fibrous nature, unlike that of any known creatures, have been washed ashore. One such hulk, 20 feet long and 40 feet around, weighed many tons.

The area of the sea is almost three times that of the land. Its average depth is more than two miles. The sea has 138 times as much territory lying 12,000 feet below sea level as the land has rising to

12,000 feet above. To bring about an even division of the areas available for life of marine and terrestrial faunas, the water level of the oceans would have to be lowered 10,000 feet.

With the great existing disproportion in area between the land and the sea, it is likely that the human race, with its seemingly insatiable mass appetite, will have to look more and more to the sea for its food.

FISH HARVEST OF ATLANTIC COAST

The story of the fishes and fisheries of the Atlantic seaboard of the United States has the fascination of a romance.

Whether we consider the biology of the species which are the prizes of the fishing fleets, the methods of reaping this harvest of the seas, or the stern battle against the depletion of the supply, there are stirring chapters at every turn.

The world annually levies a tribute upon the seven seas of almost three-quarters of a billion dollars worth of fish, of which Europe collects approximately half, the United States only one eighth, and the remainder of mankind the other three eighths.

In terms of weight, the portion collected by the United States amounts, shellfish included, to more than four and a half billion pounds. About one fifth of this annual harvest reaches the markets in fresh and frozen condition; the remainder goes to the consumer as canned, salted, and smoked fish.

For convenience in compiling statistics, the fisheries of the Atlantic and Gulf of Mexico seaboard of the United States are divided by the United States Bureau of Fisheries into the New England, Middle Atlantic, Chesapeake, and South Atlantic and Gulf districts. The New England fisheries reach from the Canadian border to the New York State line. New York, New Jersey, Pennsylvania, and Delaware comprise the Middle Atlantic fisheries district. The Chesapeake fisheries include



Photograph by H. Armstrong Roberts

TO DEVOTEES OF ROD AND REEL THE SEA YIELDS SPOILS OF BATTLE

These two channel bass, one tipping the scales at 47 pounds and the other at 23, are prizes of a day's lusty sport. The angler who hooks a big game fish may struggle for hours before bringing his prey to boat, victory trembling in the balance and the issue undecided until the very last moment.



Photograph by Luis Marden

SYMBOLIC OF FISHING'S EARLY VALUE TO THE COMMONWEALTH, THE "SACRED COD" HUNG FOR GENERATIONS IN THE STATEHOUSE AT BOSTON

On Wednesday, March 17, 1784, Mr. John Rowe "moved the House that leave might be given to hang up the representation of a Cod Fish." This effigy, made of pine and often repainted, now hangs opposite the Speaker's chair.

those of Maryland and Virginia. North Carolina to Texas, both inclusive, is the extensive territory of the South Atlantic and Gulf of Mexico fisheries.

Largest of the Atlantic fisheries both in quantity and value are those of New England, which, in 1937, produced almost 700 million pounds of seafood worth almost 20 million dollars.

Considering the fisheries of these coastal waters as a whole, one finds, helping to swell the total annual catch, upward of 100 different kinds of fish and shellfish called for by fish-eating citizens. Forty-four kinds had more than two million pounds each to their credit in the national larder in 1937.

Biologically, perhaps the most interesting of all species that figure in the returns are the flatfish—flounders and halibuts—with their changing forms and migrating eyes. By what quirk of Nature the left eyes of species inhabiting cold water usually migrate to the right side of their heads, whereas the right eyes of most species inhabiting warm water journey to the left, no scientist will venture a guess.

When they are hatched, all flatfish are of orthodox symmetrical shape, with conventionally placed mouths and eyes, but after they swim around in ordinary fashion for a little while they exhibit a tendency to turn to the one side or the other.

Immediately after this peculiar tendency begins to develop, the eye on the lower side seems to be seized by wanderlust. Stephen R. Williams, who studied this change, says that the optic nerves are so placed in the youngling as to provide for the migration.

THE ORIGIN OF FLATFISH

The first sign of the transformation is a rapid change in the cartilage bar lying in the path of the eye that is to migrate. Then comes an increase of the distance between the eye and the brain, caused by the growth of facial cartilages. In the winter flounder, three-fourths of the 120-degree migration takes place in three days. What if that should become a human habit!

The extent of the eye migration and of the flatness of the species is closely

related to its habits. The sole and the shore flounder, which keep close to the bottom, are more twisted than the halibut, the sand dab, and the summer flounder, which are more given to free swimming.

How this deviation from the conventional bilateral shape arose is a mystery. Whether there came a "sport" in the family tree at some stage of its history, or whether the deviation grew from a gradual modification of the adults under the influence of their environment cannot be said. If it came from the latter, selection naturally favored its appearance earlier and earlier in the development of the fish, until it reached the larval stage. Earlier transformation would be disadvantageous, since there is a lack of plankton—that imperative, if almost microscopic, food supply of the newly hatched—at the sea bottom, and the transformed fishlings would find a scarcity of provender at a critical period in their lives.

ANADROMOUS AND CATADROMOUS

Some species that help constitute the fisheries of the North Atlantic are anadromous—that is, they spend most of their lives in the sea, but come into fresh water to spawn. Among these are the salmon, the shad, the alewife, and the sturgeon. On the Pacific coast the most striking instance of this is the chinook salmon, which may ascend the Columbia River as far as a thousand miles, and the Yukon as much as two thousand, to find its spawning ground.

How acute the instinct is in some species to return to the streams of their infancy was proved by a Canadian experiment. Salmon were accustomed to swim up both branches of a Nova Scotia river to spawn. Fish from one of the streams were tagged. The next year it was found that marked male fish returned to the same pool in which they had been tagged before they began their journeys.

The origin of such landlocked species as the branch herring and the fresh-water salmon is a theoretical question. One explanation is that the anadromous relatives of these fishes found their way into waters from which they were unable to escape because of the blocking of outlets by geological forces in past ages. In time their changed habits led gradually to variations from their ancestors. Thus many new species have developed.

The eel has habits of spawning which are the reverse of those of the anadromous species and is thus called a catadromous fish. It spawns in salt water but always seeks out fresh-water streams in which to pass part of its life.

Until recent years the location of the eels' spawning ground was an unsolved mystery of the sea. Finally a Danish expedition succeeded in locating it in the region between Bermuda and the Leeward Islands, where the water reaches the depth of a mile.

Although they are so nearly alike that the layman cannot recognize the difference between them, and although their breeding grounds partly overlap, the European and American species neither cross nor visit one another's shores.

The eggs are laid at depths of about 650 to 1,000 feet, and the larvae continue to rise toward the surface as they grow. At this stage, and until they reach their respective shores, they are mere bits of ribbon, so transparent that the vertebrae of their backbones may be counted without difficulty. The only difference yet found between the European and American species is that the European has a few more vertebrae.

EELS AT THE PARTING OF THE WAYS

Both species start out, mayhap together, over a route neither has traveled before. But when they come to the parting of the ways, the European elver, with a three years journey ahead of it, says good-by to its American cousin, which has only a year's swim to get to its future home. By what means this unerring homing instinct is transferred from the parents, which never return, to the offspring, which must travel a road they have never been over, is a mystery that will probably long await a solution.

The spawning habits of fishes differ as greatly in other respects as in those just mentioned. Some eggs are laid at the surface and left to their fate, with no responsibilities of any kind for the parents; others are heavy enough to sink to the bottom. Some fishes, like the king salmon, lay their eggs on the stream bed, where they are covered with gravel, after which male and female drift helplessly down the stream, tail first, and die.

Some species, like the sticklebacks and the lumpfish, guard their eggs until they



International Newsreel

FISH CAME TO CHURCH IN ST. DUNSTAN'S, LONDON

In accordance with old custom, a special service was held to bless the seafood and produce from the salesmen of Billingsgate and Leadenhall markets. This ceremony, although somewhat unusual, was a sincere and devout expression of gratitude for the bounties of the deep and the wealth of the soil which meant life itself to many thousands of workers.



Photograph by Rudy Arnold

IN AIRPLANE FISHING THE ANGLER EMULATES THE GULL

He has spotted a school of fish while flying off the east coast of Long Island, tossed out floats attached to balloon buoys, and descended to the water to pull in his catch.

are hatched. The courage of the male lumpfish and his devotion to his task have often been noted. He eats nothing while guarding the eggs, but constantly fans the egg mass to keep it free from silt and bathed in flowing water. He never deserts his post save to drive away some intruder, and finally, when the eggs are hatched, he is a picture of exhaustion and hunger.

The males of other species, including some of the sea catfishes, carry the eggs in their mouths until they hatch. The females of still other species, following the example of the lobster, glue their eggs to the undersurface of their bodies. The male sea horse opens up a little pocket beneath its body, takes in the eggs from

its mate, and carries them in the tiny pouch Nature provided until they hatch. Hundreds of perfectly formed sea horses are thus liberated at a hatching, so tiny in size that the human eye can hardly distinguish them, yet perfectly formed.

Not all fishes lay eggs. Some give birth to their young alive. Among these are most sharks, the sawfishes, the rosefishes, the rockfishes, the surf fishes, and many species of top minnows.

The number of eggs laid varies widely in different species. Scientific censustakers of Uncle Sam report that the herring lays about 30,000. The sturgeon may produce as many as 2,400,000, the halibut more than 2,000,000. The cod has been known to lay more than 9,000,000.

By the number of eggs spawned, one can gauge the perils through which the several species of fish pass from the egg state to maturity. It is demonstrable mathematically that if all the eggs of a single female herring were to produce similarly productive generations, in ten years the oceans would be overflowing with herring, and all the other creatures of the sea literally would be crowded out of existence.

ENEMIES OF FISHES

Indeed, it has been proved that if only three eggs from each female of each species should develop into adult fish similarly productive, fish life would multiply so rapidly that the seas would soon become vastly overcrowded. What does happen is that, in general, a pair of cod (or herring, or any other fish) produce only two

offspring which live to maturity. The balance of Nature is so adjusted that each species maintains itself at a fairly constant level.

In this connection it is interesting to note that Nature's need for females in many species exceeds the requirement for males. In the case of the conger eel the ratio is nineteen females to every male, and in that of the herring three females to every male.

The perils fish have to face are innumerable. Huxley estimates that only five per cent of the herring destroyed annually by all herring enemies in the world find their fate at the hands of man.

The other 95 per cent are the victims of whales, the porpoise family, seals, and other mammals; cod, haddock, mackerel, sharks, and other fishes; gulls, gannets, and other birds; and the thousand and one other enemies that lurk in their wake at every stage, from the newly spawned egg to the adult fish.

MANKIND, AN ASSOCIATION OF HERRING CATCHERS

How tremendous this toll of the other-than-man enemies of the herring actually is may be gathered from the statement that man himself is credited with an annual catch of nearly eleven billion herring. On that basis we must conclude that more than two hundred billion herring annually fall victims to their enemies in the sea—enough to load a solid fish train reaching around the earth at the Equator.

Huxley has called mankind an association of herring catchers; and if those fish



Photograph by Fein from New York Herald Tribune

EELS WERE DRAINED FROM THE WORLD'S FAIR GROUNDS

When the area was being made ready for the New York exposition, great numbers of these creatures were pumped out with the water. This enthusiast holds a fat prize caught at the mouth of a pipeline.

be counted that are caught by fish which feed on them and in turn feed us, he probably has not missed the mark much.

He also reminds us that single schools covering half a dozen square miles may contain more than three billion herring; yet many schools have been recorded that covered an area of 20 square miles.

The migration of fishes forms one of the most fascinating romances of the sea. We have seen how the shad, the salmon, and other species spend their adult lives in the sea and seek fresh water in which to spawn; how the eels, on the other hand, pass their lives in rivers and lakes and seek salt water at spawning time. The mackerel and the flying fish fami-



Photograph from Ewing Galloway

AT DIGBY, NOVA SCOTIA, FISH ARE DRIED IN THE OPEN AIR

Canvas awnings must be used sometimes to shelter them from sunburning, and coops are provided to protect them from rain at night. Though steam-heated shelf driers are employed in some factories, the method tends to be too rapid for uniform results, hardening the surface and leaving some moisture below.

lies wander wide from their usual haunts at spawning time. Other species follow the great schools of menhaden about the seas, "a full dinner pail" being the first consideration in their lives as in ours.

However, for the most part, keeping a complete check on the movement of the fishes of the seas is a problem still awaiting solution. The exact winter home of the common mackerel is unknown, though a few have been caught with cod lines in deep water off Grand Manan, and others have been taken from the stomachs of cod on Georges and La Haye Banks, as well as off the coast of New Jersey.

TAGS TELL THEIR STORIES

For a long time it was supposed that the hickory shad spawned in fresh water streams, as is the habit of its near relatives, the branch herring and glut herring. But investigations in the Chesapeake Bay region failed to reveal any young which might have been produced in the tributaries of the Bay. The hickory shad's spawning grounds have not yet been located.

The spawning grounds of the tuna have never been discovered. This fish has successfully eluded every effort to trace its tracks through the deep seas.

Extensive tagging and scale studies by the Bureau of Fisheries have revealed the general pattern of the strange comings and goings of the weakfish.

The migratory movements of herring are so complex that, although ichthyologists have been trying for many years, a complete solution has not yet been found.

In past years, the United States Bureau of Fisheries, by marking cod, pollock, and haddock, made careful studies of their migration habits. Recently, the Bureau has been attaching inscribed tags of metal or celluloid to thousands of flounders, weakfish, shrimps, and other species. After marking, the fish are returned to the sea, in the hope that fishermen of the waters they inhabit will return the tags of those caught, with information about the locality in which they were taken, a record of the date, and of their size. For each tag returned, the fisherman receives a small



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OVERFISHING KILLED THE FISH THAT LAID THE GOLDEN EGGS

Once sturgeon abounded in the Delaware River, New Jersey, but the fishery was so relentless that today the taking of one is a rare occurrence. A specimen captured in a year of plenty was 10 feet 3 inches long, weighed 450 pounds before it was dressed, and yielded 103 pounds of roe. With the flesh selling for 50 cents a pound and caviar for \$2.75, the fish brought \$350.



"KING HERRING" HANGS HIGH IN A LOCKEPORT, NOVA SCOTIA, SMOKEHOUSE

No other fish contributes so much to the support of the human race as this common species. It swims closely packed in schools that often darken water areas of six to twenty square miles. In Maine large quantities of the small fry are canned as sardines. One authority estimates the annual destruction of herring by man at eleven billion—about seven to each person in the world; yet despite this huge drain the supply is not greatly diminished.

reward and the thanks of the Bureau of Fisheries for his assistance to science.

In the tagging operations the fish are caught in nets or with hook and line. The uninjured fish is laid on a wet board, measured, and its exact length recorded. A metal or celluloid tag stamped U. S. B. F. is then securely attached to the body, to a fin, to the tail (the placement of the tag depends on the species). More recently the tag may be inserted in the abdomen. The fish is released at once and a record is made of its number, its size, where it is released, etc. Fishermen have gone to the trouble of assisting the Government by reporting to Washington when such fish are taken. Many thousands of returns have been thus recorded and others continue to flow in.

A study of the anatomy of fishes and the evolution of some of their organs throws an interesting light on life in the ocean.

WHY FISH HAVE SPHERICAL EYES

In order to see under the water, the eyes of the fish had to be constructed on lines differing somewhat from those of man and land animals. Dissecting a fish's eye, one discovers that the crystalline lens is almost a perfect sphere instead of the somewhat flattened lens of land animals. This arrangement is necessary to sight in the water, since the difference in density between the lens and the water is so slight. The result is that fish are extremely near-sighted.

While it is probably true that fish do not "hear" sound waves in the air, they seem to react promptly to disturbances in the water. Whether or not this sensitivity to underwater "waves" should be called "hearing," it is practically utilized in driving fish into nets. To produce "noise"



LAW PROTECTS THE FEMALE LOBSTER "IN BERRY"

The number of eggs produced by an individual varies from 3,000 to 100,000, according to its size and age. They are glued to the under-surface of her body, and carried around for about ten months before hatching.

in the water, fishermen beat the surface with a flat object or stamp on the bottom.

What we know as the fish's ears are largely organs of equilibration, as they are to some extent in man.

The sense of taste appears to be largely wanting in fish. Their tongues are without power of motion and lack delicate membranes. They swallow their food very rapidly and usually without mastication, further than getting it small enough to gulp down.

FISH, LIKE MEN, NEED OXYGEN

Out of water, a fish dies of suffocation because it cannot extract oxygen from the atmosphere. Only oxygen dissolved in



Photograph from Keystone-Underwood

COD IS KING AT GLOUCESTER, MASSACHUSETTS

Proudly a fisherman holds a handsome prize taken on the banks out from this famed port, where for generations men have gone down to the sea in fishing boats.

water can be utilized through the vessels of the gill filaments. Some species, like the catfishes, can live for a considerable time out of their native element. A man requires 50 times as much oxygen as a fish of equal bulk.

The air bladders or swim bladders of most fishes help them to solve admirably their respective problems of hydrostatics. Bottom fishes have small ones, and species that range between the surface and the bottom have relatively large ones. The gas with which air bladders are filled is secreted from the blood in most species.

The evolution of the air bladder from a respiratory organ and the perfection of the gills to a point where they furnish oxygen enough, and therefore render the air bladder useless for breathing, may be traced in species still existing. In the more primitive fishes, gills were the principal organs of respiration, but the air bladder served as accessory "breathing" equipment, a function which it has lost

in the more specialized fishes. The primitive connection between the air bladder and the gullet is retained in the soft-rayed fishes, such as the herrings, eels, trouts, and salmons. While these species may renew the supply of oxygen in the air bladder by coming to the surface and "gulping" air, respiration is carried on chiefly through the gills.

Some fishes have no air bladders: for example, the sharks, skates, flatfishes, pipefishes, adult mackerel, some species of tunny, and some rockfishes.

The major fins of fishes correspond strikingly to the limbs of land mammals. Those back of the gills are known as the pectoral fins and correspond to the arms of humans. If the bones to which they are attached are examined critically, they will be found somewhat similar to the shoulder girdle of land mammals.

Below the pectoral fins are the ventral fins, which correspond to the hind legs of quadrupeds. The dorsal fin on the



Photograph by Willard R. Culver

A FIGHTING TUNA COMES ABOARD AT BLOCK ISLAND

Game fishing for this splendid species is rapidly coming into popularity here off Rhode Island, off Montauk Point, Long Island, on the New Jersey coast, and at Ocean City, Maryland. Throughout the summer, week-end parties come from New York, Boston, and all New England to match skill and endurance against the supreme gamesters of the sea. Swordfish and bluefish add to the thrills of this anglers' paradise.

back, the caudal fin at the root of the tail, and the anal fin beneath the body are used to maintain equilibrium or direction.

NATURE'S BREEDING METHODS

Nowhere is the art of camouflage more strikingly employed than in marine life. The master breeder of the ages, Nature, has provided certain, if very slow, methods of eliminating the unfit from reproduction.

One method is by tests of brute strength, as in the battles of bull fur seals; another is by the elimination of the sluggards, as in the pursuit of the herring by the mackerel. A thousand and one methods are available.

None is more nearly certain among fishes than that which removes those failing to make proper use of the art of camouflage. Note the hues of a herring in the color plate. Its back corresponds to the shades of the water in which it thrives; viewed

from the air, it has low visibility. Its belly corresponds to the appearance of water when viewed from beneath the surface. The fishes best protected by their camouflage escape their enemies most frequently, and therefore have a better chance to reproduce. The ones that are least protected fall victims more easily, and therefore are less likely to reproduce.

USING THE ART OF CAMOUFLAGE

Thus, even if ever so little in each generation, the process goes on—ever the better fitting each and every thing that reproduces life to the environment in which its fortunes are cast.

The flounder, the halibut, or the sand dab, lying on the sand, has harmonizing blotches imprinted all over the upper part of its body, imitating the various kinds of sand on which it lies, whether that be common brown sand, crushed coral, or rotting



Photograph by Arnold L. Belcher

HOME FROM SEA, FISHING BOATS ANCHOR NEAR BOSTON'S CUSTOMHOUSE TOWER

Though the Massachusetts capital is known as "the Athens of America," it proudly acknowledges its debt to the industry that gave it its prosperity; and its water front has lost little of the saltiness of the heyday of "king cod."

lava. The least successfully camouflaged individuals face the greatest peril and the most successfully concealed ones enjoy the greatest safety.

Man's successes in breeding horns off the ox, the long nose off the wild boar, and great size into draft horses are but a few passing examples of throwing Nature's processes into high gear and hastening the transformation. Man has done less in this respect with the fishes than with almost any other form of life, for the reason that he has had less control over them.

But, even at that, he has been able to breed pugnacity into fishes, as witness the fighting fish of Siam, where the natives stage fishfights as exciting to them as are cockfights to the masses in Spanish America.

While not a fish, the lobster, belonging to the crustacean group of animals, supports one of the most interesting and important fisheries of the American shores of the North Atlantic.

The lobster, biologically, is a closer relative of the spider than of the fish. The



Photograph by Press Illustrating Service

FISH CLEANERS ATTAIN PHENOMENAL SPEED AND SKILL

At St. John's, Newfoundland, as at other famous North Atlantic ports, many men devote virtually their whole lives to this humble work. There are hard-fought contests for local, national, and international championships.

problem of saving the lobster fisheries from utter depletion is one of the most difficult with which the fish culturists have to deal.

The American lobster is found only on the eastern coast of the United States. Its known range covers a strip of the North Atlantic reaching from Labrador to North Carolina, with the Maine and lower Canadian shores as the region of its greatest commercial abundance. This strip of water is from 30 to 50 miles wide and from 6 to 600 feet deep.

THE LOBSTER'S HABITS

From the close of its early free pelagic life to its old age, which often stretches into decades, the lobster never leaves the

sea bottom of its own accord. Its external world is the ocean floor, and it is content to stay there.

Having considerable power of locomotion, it wanders around as winter approaches, from the shallow inshore waters to the deeper ones of the 100-fathom line, searching for water of comfortable temperature and for suitable food, and attending to the duties of reproduction.

Its instincts constantly lead it to conceal itself, sometimes to take its prey unawares, and at others to hide from its natural enemies.

It walks over the sea floor on its slender legs, which are provided with brushes of sensitive hairs. With its large claws put



© H. Armstrong Roberts

"GRAMPA, WHEN I GROW UP, CAN I MEND NETS TOO?"

For generations Atlantic fishermen have taught their skills to their sons and grandsons. The gear with which they comb the seas for food for man is of many kinds and divers types, and a boy who masters all the intricacies of the business must begin his lessons at an early age. There is true romance in the profession, which is one of the oldest means of human livelihood.

forward to offer little resistance to the water, it keeps its "feelers" waving back and forth continually to detect danger as well as to discover game its eyes may have overlooked.

SCAVENGER OF THE SEA-FLOOR

The buoyancy of the water makes the lobster light on its feet in its native environment, but its body weight is too great for its legs when out of water.

Though a great scavenger and tending to be nocturnal in its search for food, the lobster, it is believed, prefers fresh food whenever that is available. Fresh codfish heads, flatfish, sculpins, sea robins, menhagens, and haddocks make excellent bait; but balls of putrid, slack-salted herring seem just as attractive.

When hungry, the big crustacean will burrow in the sand like a ravenous pig rooting for grubs, and it has been known to attack even a full-sized conch, breaking its shell away, piece by piece, and gluttonously devouring the soft parts.

The lobster is a cannibal by nature, preying on its weaker brethren, and did not the conditions under which it is hatched favor its immediate and wide dispersion, it would largely exterminate itself.

Like dogs, lobsters have frequently been observed to drag dead prey to some secret spot, bury it, and then mount guard over the cache, ready to defend it against all comers. Often grim battles are fought over such caches. Indeed, few of the giant lobsters that have been taken are without numerous scars that tell in no uncertain language of pitiless struggles to which they have been party, where quarter was neither asked nor given.

In the American Museum of Natural History in New York is preserved a giant lobster the living weight of which was 34 pounds. It was captured at Atlantic Highlands in 1897. The Smithsonian Institution has one of which the living weight is estimated at 25 pounds. Both of these were dwarfed by a 47-pound lobster taken in the southern winter trawl fishery in the 1930-1931 season.

Dr. F. H. Herrick, the author of the United States Bureau of Fisheries' striking study of the American lobster, thinks that all of the thirteen titans he lists as weighing more than 20 pounds were not giants by nature, but rather simple favorites of fate, which allowed them to live

to a riper age than their smaller fellow creatures. Good luck never deserted them until they became stranded on some inhospitable beach or entangled in some fisherman's gear. Such lobsters as these, he believes, have weathered the perils of at least half a century.

Few living creatures have such striking habits of changing their clothes as the lobster. It begins to molt or discard its outgrown clothes the second day after hatching, and continues to do so with decreasing frequency until it has ceased to grow at all.

Nowhere else in Nature is the molting process so striking, so critical, or so abrupt.

When the old shell becomes too small, a new skin begins to grow underneath it. When this growth nears completion the lobster becomes a "shedder," ready to cast off not only its old shell, but even the lining of its esophagus, stomach, and intestine.

Specimens under careful observation have been found to be restless and uneasy as the time of the molt approaches. Suddenly there comes a break where the tail joins the shell. The lobster then turns over on its side, bends itself in the shape of a "V," with the break at the apex. Pressure is applied, and gradually the rear end of the shell breaks loose from the new one beneath.

"WIRE PULLING" A CLAW IS A REMARKABLE PART OF LOBSTER MOLTING

Step by step the process of liberating the imprisoned body from its outgrown armor sweeps forward until finally the claws are withdrawn through the narrow openings. Presently, with a mighty effort, the lobster emerges from its old coat of mail, casts off the linings of its digestive tract, and steps out, full-panoplied in a soft new shell.

The area of a cross section of the flesh in the largest part of one of its big claws is four times greater than that of a cross section of the second joint, through which it must be drawn. The process, therefore, reminds one of pulling wire through the holes of a drawplate.

From six weeks to three months are required for the soft-shelled lobster to become a hard-shelled one again.

The lobster has many enemies; but, next to man and his alluring traps, the codfish ranks as its worst foe. With an appetite that doesn't stop at a hard shell up to eight inches, and with a particular taste for young lobsters from two to four inches in



International Newsreel

CHESAPEAKE BAY MENHADEN MAKE HAM AND EGGS

Though unsuitable for human consumption, these fish, dried and flaked, cause hens to lay better and hogs to fatten in record time. They have been sought for years by fishermen with specially constructed ships. They are cooked, pressed for oil valuable in soap and paint making, and then converted into fertilizer and stock food.

size, the codfish is a tremendous competitor of the lobster palace in the race for survival of the fittest.

MESSMATES PRESENT THEMSELVES

During their younger lives, lobsters play into the hands of millions of foes in the sea, for it is not until the fourth or fifth stage that they leave the surface for the bottom. It is not until this period that caution seems to dawn in them and guide them to hiding places on the sea floor. During the lobsters' earliest periods, vast schools of surface-feeding fish strain the water through which they chance to pass

as effectively as might a towed net.

Though only a few parasites of the lobster are known, it has many messmates. Barnacles affix themselves to its shell and cement their tentlike coverings thereon; different kinds of mussels insinuate themselves into attractive depressions in the carapace and joints. Tunicata sometimes fasten themselves on the under-surface of the body, between the legs. Tube-forming annelida, lacelike bryozoa, and several forms of algae make themselves unbidden guests, which the uneasy host can cast off only when it molts.

Grain-eating birds swallow their food whole and, with the aid of gravel or other hard material, pulverize it in their gizzards. The lobster handles the situation differently. It chews its food before passing it into its mouth. The cutting teeth of its outer mouth parts chop the material into mincemeat,

which is passed into the mouth proper in a slow stream of fine particles. From there the food reaches the stomach, which is divided into two parts—the forward section for storage and the rear compartment for sorting, straining, and digesting. Between the two are three teeth, one upper and two lower, which, like upper and nether millstones, grind the food to its appropriate degree of fineness.

WHAT SELF-AMPUTATION MEANS

When one examines a lobster carefully, it is seen that the two great claws do not terminate alike. The one ends with a

large crushing type of pincers and the other with a seizing type. One of the strange things in connection with these great claws is that Nature has given the lobster power not only to amputate them in case of danger, but to grow others in their place after amputation occurs.

Imagine a man with his hand caught in a machine suddenly giving a severe jerk and severing his arm at the elbow! And then imagine him going off to himself and growing another arm to take the place of the lost one! That is comparable to what the lobster does.

In a census of more than 700 lobsters, 7 per cent were found to have thrown one or both great claws, and these showed every stage of the regenerative process. Nature has arranged matters so that no tendons or large blood vessels cross the breaking point; hence there is little bleeding at the operation.

That the self-amputation of the claw is a matter of will is shown by the fact that when put under an anesthetic the lobster "forgets" to amputate the captive member.

ABUNDANCE OF FISH—YET OVERFISHING

When the female lobster lays her eggs she turns over on her back, using her large claws and her tail-fan as a tripod to support herself. She flexes her abdomen to make a sort of pocket, to which she glues the eggs fast. An 8-inch female will lay about 5,000 eggs, a 10-inch individual



Photograph by J. Baylor Roberts

WILL YOU HAVE YOURS GRILLED, STEAMED, OR IN JAMBALAYA?

The six-crew schooners that took out shrimp seines many fathoms long have given way to motor trawl boats handled by only two or three men. As the power craft moves along, it drags a U-shaped trawl to catch the prey. Some trawlers remain a week or more at sea, transferring their catches to freight boats. With the single exception of oysters, shrimp exceeds in value any other fishery species of our Atlantic waters. The 1937 catch of more than 141,000,000 pounds had a value of about five million dollars.

about 10,000, and an 18-inch one some 80,000, there being about 6,000 eggs to the ounce (see page 19).

The eggs are carried about for ten months. After hatching, the larvae pass from three to five weeks irresponsibly floating around near the surface, somewhat lacking in the powers of coördination and orientation. During this time they undergo four molts. At the third molt after hatching the lobsters begin to take on the characteristics of the adult. At this state the instinct to desert the surface and seek



Photograph from Canadian Motion Picture Bureau

DEFT HANDS DEMONSTRATE THE MEANING OF "TIGHT AS A SARDINE IN A CAN"

Packing of young fry had an early origin on the Maine coast as a more lucrative outgrowth of the herring industry. Unlike the shad and alewife, which are also called herrings, the true species is strictly a sea fish and does not enter fresh water. Schooling along the shore during the warmer part of the year, the herring apparently retreats to deep water when winter comes. Spawning takes place near shore. The quantity of tinned fish has increased by leaps and bounds, salmon ranking first, the tuna and tunalike fishes second, and the sardine third. The total value of canned fishery products in 1937 was more than \$100,000,000.

the bottom suddenly asserts itself, and the lobsterling settles down to its new environment to eat and grow, reaching maturity in five or six years.

While the ocean literally teems with life, man has learned to make comparatively small use of it, and the list of fishes fit for food is inestimably longer than the list of food fishes. The things yet to be found out about marine creatures are vastly more numerous than the things already discovered.

Yet on every hand one already sees the results of overfishing on many of the species now entering the fish markets.

The easily taken anadromous fishes, par-

ticularly the shad and the Atlantic salmon, are growing scarcer and, consequently, higher-priced with each passing year.

Between overfishing and stream pollution, the fresh and brackish coastal waters are seeing their fisheries depleted rapidly toward the vanishing point.

The Atlantic salmon has disappeared from many rivers. Along the Maine coast the catch has dwindled to one-tenth of what it was in 1880, and there was an even greater decline before that year. The Housatonic, the Thames, and the Saugatuck are Connecticut rivers which once were nationally famous for their salmon, but which now yield none.



Photograph by Edith S. Watson

ST. PIERRE FISHWIVES BEHEAD CAPELIN

The Islands of St. Pierre and Miquelon, ceded by Great Britain to France as shelters for her fishermen by the Treaty of Paris, 1763, are now only relics of the once great French empire in America. Both were formerly very valuable as stations from which France carried on her fisheries on the Banks of Newfoundland. St. Pierre is the smaller, but the more important of the two, and the little town of the same name presents a busy aspect during the fishing season. The American capelin was so called because early French fishermen saw a resemblance to the European *capelan*, a small cod, but the American fish is classed as a smelt.

The story of the shad is one of steadily declining fortunes. Early decades of abundance were followed by a period of increasing scarcity in the Potomac, the Susquehanna, the Hudson, and the Connecticut rivers. In the Hudson, the shad has staged a "come-back." In recent years, near-record catches have been made in certain waters where this fish had been despaired of.

A condition of steadily diminishing supply prevails in the shellfish fisheries. Oysters, in spite of Federal and State watchfulness, are disappearing from beds where once they were plentiful. The story of the many decades of depletion of the

lobster fishery is told in every area where the fishery exists.

In colonial times lobsters were so plentiful that even the poorest of the people might feast to their heart's content on this succulent crustacean.

Even as late as 1889 the catch in the United States reached a total of 30,000,000 pounds, which sold for \$800,000—less than three cents a pound. Ten years later the catch was only half as large, while the price had more than doubled.

In 1880 Maine produced 14,234,000 pounds, which sold for less than two cents a pound, as compared with 7,348,500 pounds in 1937, which sold at nineteen

cents a pound at the wharf, and heaven only knows at how much to the ultimate consumer. The catch of Maine alone, in 1887, was twice as great as the total catch along the Atlantic coast of the United States in 1937.

Where stream pollution is the chief cause of the decline of the fisheries, nothing except radical protective legislation to save the streams will avail. The Government has found that a pound of bark to 30 gallons of water will kill bass in one day, and that even a pound of chips to seven gallons of water is fatal to salmon fry.

If such simple pollutions as these destroy fish wholesale, what destruction is wrought by oil and tar, sludge and bilge!

Overfishing may be combated in two ways—by artificial propagation and by restricting the catch, either as to season or as to size of fish—in short, applying common sense.

Artificial propagation has proved its value in the case of fresh-water and anadromous fishes. The shad fishery has been bolstered by the artificial propagation activities of the U. S. Bureau of Fisheries. The same is true of the salmon.

For marine fishes, authorities differ as to the value of methods at present employed. As new knowledge of the sea is gathered, however, there come reasons to believe that conditions may be established under which artificial propagation can be made a success.

It has been found lately that there is a dangerous age for the fry of fish, just as there is for the children of men. We know that the number of children who die between the day of their birth and their second birthday exceeds the number who die between the ages of two and twenty-two. The reason is the high mortality from diseases of infancy.

Likewise, it has been demonstrated that the first few weeks of a fishling's career constitute a high mortality period, in which hundreds die where one survives.

PLANKTON IMPORTANT IN ITS RELATION TO FISH LIFE

If safe artificial methods could be devised to bring the fry past the critical period, their chances of survival would be vastly improved. It has been found that usually this period of wholesale decimation is reached about the time of the absorption of the yolk sac.

Apparently at or before this stage, minute forms of plankton—the mass of passively floating or weakly swimming plant and animal life near the surface of the sea—are needed as food by the fry that can no longer draw on the yolk sac for nourishment, and without this plankton they die.

The scarcity or abundance of plankton has been found probably to depend upon weather conditions generally, and the examination of the scales of the fish reveals that in any school of adults there is a great preponderance of some particular age. Study of case histories reveals that this class coincides with the year most favorable to the development of plankton.

FISH MAY PASS THE DANGEROUS AGE

This affords a clue to the discovery of a method by which marine hatcheries may bring their salt-water fry past the dangerous age before releasing them—a technique still in an experimental stage.

This line of investigation shows how important the study of marine life is, what invaluable revelations it may yield, and the splendid character of the results that may be attained therefrom.

To meet the alarming decline of the lobster fishery, the several States interested in its protection enacted various laws. Some have provisions for a closed season, in which the taking of this crustacean is forbidden. Laws prohibiting the destruction of female lobsters “in berry”—that is, carrying their eggs after laying them—have also been enacted.

In addition to the protection thus offered, attempts have been made to propagate them artificially, by hatching and liberating the fry.

Existing policies have somewhat checked the decline, but recent studies still show that new forms of protection and propagation must be adopted if the fishery is to be saved. The late Dr. Francis H. Herrick, America's foremost student of the lobster problem, proposed the abolition of the closed season, which he considered a futile practice. He suggested adoption of a double gauge under which traps would be prohibited that did not permit the escape of all lobsters under 9 inches, and make impossible the entrance of all over 11 inches. He also would have forbidden the capture or sale of all below or above that limit; would have protected the

"berried" lobsters and fixed a bounty for each one delivered to the fishery authorities. He proposed rearing young lobsters to the bottom-seeking stage in hatcheries, thus liberating them when the perils of infancy are past.

Maine, which produces the bulk of the United States' catch of American lobsters, has adopted a double gauge for traps, protecting both the young lobsters and the extremely fertile, largest individuals.

FISHES OF GEOLOGIC HISTORY

Jordan observes that when a fish dies it leaves no friends. Its body is promptly attacked by scores of scavengers, ranging from the one-celled protozoa and bacteria to members of its own species. The flesh is soon devoured, the gelatinous substance of the bones decays and leaves the phosphate of lime content to be absorbed by the water. Hence the multitudes die without leaving any trace behind. Once in a great while a few teeth, or a fin spine, or a bone buried in clay may endure, but the exceptions are notably rare.

It is because of this condition that few traces of the earliest fishes of the geologic past have been left. An expedition from the Smithsonian Institution some years ago unearthed near Canon City, Colorado, what are believed to be the oldest fish remains known to science. They come down from the Lower Silurian age, a time when neither man nor mammal, nor reptile, nor any other living land animal with a backbone, had yet appeared—a time, indeed, when some of the deepest sandstones we know were being laid down. (See "Compleat Angler" Fishes for Fossils, page 349.)

FORCES OF DISTRIBUTION STILL AT WORK

From early geologic times many elements have played important roles in determining the distribution of the several species of fish. We see those same forces at work today.

Available statistics show that, during the years from 1929 to 1935, the catch of bluefish in New England waters averaged more than 600,000 pounds annually, while in the Middle Atlantic section the yearly catch averaged more than 3,600,000 pounds.

In the case of cod, the situation is reversed, more than twenty times as many cod being taken north of Long Island as south of that latitude.

There are few herring in waters between Long Island Sound and Delaware Bay, while the menhaden are tremendously abundant there. Temperature is regarded as the principal influence in thus separating the fishes in these two parts of our North Atlantic waters. There are some species that seem to be equally at home above or below the latitude of Long Island, such as the alewife, the butterfish, and the scup.

Boston is easily the fishing capital of the New World, and yields only to Hull-Grimsby, England, as the world's leading fishing port (see illustration, page 22).

In the Atlantic fisheries, Canada has about 43,000 men employed, as compared to about 75,000 for the United States.

MENHADEN LEADS IN WEIGHT OF CATCH

In the United States' Atlantic and Gulf of Mexico fisheries as a whole, the menhaden takes first rank in the weight of the catch, with the enormous total of more than 482,000,000 pounds!

There is a wide gap between the menhaden and the next group, which includes the haddock, with 172,000,000 pounds, and shrimp and cod, each with 141,000,000 pounds, as the approximate weights of their catches for 1937.

There is another considerable gap, followed by the group with catches of between 50 and 100 million pounds: oysters—87,000,000 pounds (with a value greatest of all Atlantic fishery products), hard crabs—77,000,000, flounders—61,000,000, rosefish—58,000,000, herring—53,000,000.

The next group includes species that, in 1937, yielded annual catches of between 25 and 50 million pounds: croaker—49,000,000, weakfish—42,000,000, pollock—38,000,000, whiting and mullet—36,000,000 each, alewives—30,000,000, mackerel—27,000,000, hake—25,000,000.

Kinds landed in annual catch weights from 10 to 25 million pounds include: scup—19,000,000, soft clams—17,000,000, hard clams and lobster—both with about 12,000,000 pounds, and cusk—10,000,000.

Among species with recent annual catches between five and ten million pounds are: butterfish and shad—each with almost 10,000,000 pounds, spot—9,000,000, bluefish and red snapper—8,000,000 each, Spanish mackerel—7,000,000, and soft crabs—6,000,000 pounds. The figures given are all for 1937—the latest obtainable.



Photograph by H. Armstrong Roberts

HO FOR THE ROAR OF ATLANTIC SURF AND THE TUG OF A FISH ON THE LINE!

For the man who has no boat to carry him out where the schools of big fighters play, the sea provides thrilling sport that tests both skill and endurance. Angling from the wave-beaten shore is a game far more exciting than sitting peacefully on dock or river bank.

The wealth of the United States and the high per capita income of the people have made them able to indulge their whims rather than their needs for food. Therefore the food they select, both from land and sea, has been chosen more from the standpoint of flavor than from that of nourishing qualities. Thus in prosperous years choice cuts of meats and the choice species of fish are taken and all too frequently the remainder not properly appreciated.

We have been particularly slow to adopt new salt-water fishes into our diet. Still, tastes do change, even if only gradually. What was ignored yesterday comes into the market today, and tomorrow it acquires a vogue.

It is not so long ago that the pollock was in such small demand that it was scarcely worth the taking. So also with the tuna. But today both find ready sale. On the Pacific Coast, tuna has been canned extensively for years. Beginning in 1937, quantities of Atlantic tuna have been packed in response to a growing demand.

The flounder, likewise, used to be eaten only by the initiated few; but now it is one of the most ready sellers. So it has been with the haddock and certain salmon, principally the humpback.

The growing popularity of sea mussels and tilefish shows how the public taste can be trained under proper guidance, and as the population of the country grows we shall follow Europe in the utilization of marine resources to supplement our land crops. Today we eat only about half as much fish per capita as the people of Europe, and have only scratched the surface in promoting the utilization of our food-fish resources.

Three basic handicaps—perishability of the product, unevenness or uncertainty of supply, and unsteady consumer demand—have hindered until recent years large-scale development of the fresh-fish industry.

FRESH FISH TO EVERY MARKET

Other products have one or two of these handicaps: milk is perishable, but considered imperative; canned goods have an uneven demand and supply; but only fish suffer from all three conditions.

But lately ways have been discovered to overcome the perishability of fish. Methods of precooling have been found by which the fish can be frozen in low-temperature

brine as soon as they are taken. Thus is insured the thorough cooling of every shred before chemical change sets in.

Then the fish is encased in an individual film of ice and sent to market. The housewife who buys her fish in this ice jacket can then know it is perfectly fresh, having been kept so from the hour it was caught.

A fresh fish bought in a market stall is seldom as fresh as a frozen fish precooled when caught, and now that this type of frozen fish has become widely available, the zone in which marine fishes are eaten fresh reaches far back from the coasts to include principal mid-western cities.

Other methods of obtaining new patrons of the marine fisheries have been tried with success. Wholesale fish dealers are putting up choice cuts of haddock in consumer packages wrapped in parchment paper. These packages find favor and ready sale as far away as Denver.

TROUT RIDE THE RAILS

A Boston forwarder took an enlightened step in another direction in the extension of the fresh-fish market. He undertook to gather the less-than-carload lots of fish consigned to Philadelphia or other cities and to ship them through in carload lots with a large saving of transportation costs and increased expedition in handling.

A Canadian fisherman has tried shipping live lake trout to New York, with striking success. He sent in one shipment 6,000 pounds of trout. They were put in four wooden tanks seven feet square and five feet deep, which were placed in an ordinary box car. By means of a kerosene-driven engine the water was kept constantly in circulation. Casualties in transportation were only about 15 per cent, and it is possible that in the future the fastidious can enter their favorite restaurants, peer into a pool, and select the fishes they want to eat—that is, if the demand is great enough to warrant the regular deliveries.

That fish from the sea will help solve the food problem of America whenever it becomes acute is shown by the fact that analyses reveal how readily fish can be used as a substitute for meat.

Fresh salmon has more nutrients in it, for instance, than round steak; shad, more than chicken.

The United States Bureau of Fisheries has foreseen the day when exact knowledge



THE SPORTY SALMON COMES FRESH TO AMERICAN DINNER TABLES

Each of the beautiful specimens from the fishing communities of our northern coasts and Canada rides into American markets in a special cold berth. Fish thus packed have been shipped 800 miles inland without deterioration.

of the marine and fresh-water conditions that make for an abundant fish supply will be one of our major concerns.

It recognizes that, without exact and definite knowledge of all phases of marine biology affecting the lives of the fishes suitable for human consumption, efforts to utilize the food resources of the sea to the fullest advantage must be handicapped so sorely that species which might render rich returns will be neglected, while others that have met with great favor may be all but exterminated.

SHAD FOR THE PACIFIC

The Bureau's work in introducing the shad into Pacific waters and making it abundant through 2,000 miles of coastline has been a service of the first order. Its success in saving the Atlantic salmon and the shad from extermination in such eastern rivers as have not reached the critical stage of pollution is another instance of its unusual value to the Nation. Its rescue of the fur seal fishery from destruction and its protection of the Alaskan salmon fishery from inordinate depletion have earned for it a general appreciation.

Yet these activities are but a prelude to the things that remain to be done.

Thanks to the splendid achievements of the past, in which such distinguished scientists as Goode, Jordan, Evermann, Nichols, Gudger, Bigelow, Barbour, Parker, Eigenmann, Townsend, Hildebrand, and numerous others have rendered an inestimable service to humanity by their gradual pushing back of the horizon of marine life, ichthyology today stands at a point where a correct appraisal has been made possible of the problems remaining to be solved in order to develop for an ever-expanding race all the potential treasures of the sea.

SALT-WATER GAME FISHES

It is an interesting coincidence that most of the game fishes of salt-water habitat belong to those species that are favorites as food fishes. The lure of the trout stream and bass-abounding waters, and the fascination of pursuing the pickerel and the muskellunge, the pike and the grayling, have brought thrills to millions who have the urge to cast a line in fresh water.

But the man who originated salt-water fishing with rod and reel, where the sport



Photograph by B. Anthony Stewart

A HOLDFUL OF "SARDINES" IS SHOVELED OUT AT EASTPORT, MAINE

Cannery employees can roughly estimate the size of their day's work by the way the incoming herring boats ride the water. If they lie low and move slowly, they are heavily laden. This load was judged to be from 25 to 40 hogsheads.

really begins when the game is hooked, where hours of battle are often required to bring the valiant fighter to gaff—hours in which the crown of victory trembles in the balance between fish and fisherman—that man created a sport which is the last word as a contest of human skill and piscatorial gameness.

Widespread angling with rod and reel for salt-water fishes is of comparatively recent origin, but when done "according to Hoyle" it makes the battle between fish and man a fight that gives the fish something akin to an even chance, and can be won by the fisherman only through the exercise of his skill and patience.

"THE LION, TIGER, AND ELEPHANT TRINITY"

The tuna, the weakfish, the striped bass, the bluefish, the tautog, the sheepshead, and many others all offer sport with as many of the thrills as tarpon fishing affords when each is caught with the tackle prescribed by sportsmen's associations for battle with the respective species.

One authority has called the tarpon, tuna, and jewfish the lion, tiger, and

elephant trinity of the angling world. Yet the real sport is bringing them to boat with seven-foot rods weighing not more than 25 ounces and lighter, although there may be from 100 to even 400 pounds of game and fighting fish at the other end of the line!

It is a battle royal when one of these resourceful and unrelenting denizens of the deep is well hooked by a successful strike, and reel wars against fin and tail—a battle that the novice is likely to lose at first and that even the veteran of many victories cannot count as won until his prize is boated.

The tuna is an inhabitant of many seas. In North Atlantic waters it used to be known only as the horse mackerel, although now "tuna" is the more common name. In the North Sea it is called the tunny, in the Mediterranean sometimes the great albacore, and in California and southern Florida waters again the tuna.

In the vicinity of Santa Catalina Island, California, tuna angling has reached a high-water mark as a sport. The angling ground is a narrow, four-mile stretch of coast in the lee of the island mountains where there are several small open bays,



Photograph by Gilbert Grosvenor

GEAR CREAKS AS A CAPE BRETON PRIZE IS HAULED ABOARD

Giant of his tribe, the North Atlantic tuna sometimes weighs as much as 1500 pounds. European varieties do not attain more than a third of that size, and those on the California coast are still smaller.

generally smooth, with wind blowing only a part of the day. The Gulf Stream off the Florida coast and south along the Florida Keys is also a favorite hunting ground. Many record tuna are annually taken in the teeming waters about Bimini and Cat Cay in the Bahamas.

In recent years angling for giant bluefin tuna in the coastal waters of New England and Canada's Maritime Provinces has attained great popularity. Now an international tuna tournament is held every year in Nova Scotian waters. The tuna reaches its greatest size in the North Atlantic.

Such a fine fighter needs special tackle, if it is to be taken in true sportsman's style, and if that tackle isn't the best that inge-

nuity can devise and money can buy it is safe to wager long odds that the prize will not be captured.

TAMING THE TUNA

Special boats are required for tuna fishing as a sport. They are broad-beamed launches, built for one or two fishermen and the boatman, who serves as engineer, helmsman, and gaffer. Each boat is equipped with a sturdy gasoline engine.

Once a successful strike has been made, the game is to bring the quarry to the boatside with rod and reel. A little too rigid holding of the rod, a momentary failure to keep the line taut, a little lapse of skill in the manipulation of the reel—in short, any one of a dozen kinds of mishaps and the battle is lost or begun again. Leaping into the air, dashing hither and yon, diving, darting, and fighting every inch of the way, the great fish gives battle. Often the contest lasts for hours; sometimes the fight ranges over a several-mile sector.

In California flying fish is the bait on which the tuna strikes best. The latter come in large schools between the middle of May and the last of June, and generally divide into schools of from fifty to a hundred.

For a while they play around on the surface; then suddenly there is a great splash and the fretted waters turn into a boiling spray; the tunas have sighted a school of flying fish, which skim along in a frenzy and wild confusion trying to escape from their natural enemies. That is the signal for which the fishermen have been waiting, and the sport is on.

In the North Atlantic companies of tuna pursue the schools of herring into bays or tide rips between islands. And there many a tuna swallows a herring deftly threaded

on a large steel hook!

The tarpon is not classed as a food fish, although smoked and used in Cuba, but it is to South Atlantic waters all that the tuna is to the North Atlantic and the Pacific, the acme in sea sport fishing.

The credit for originating the sport of tarpon fishing belongs to William S. Jones, of Philadelphia. Back in the late eighties he was fishing in the Indian River Inlet, in Florida, and chanced to hook a 130-pound tarpon which was six feet long. For two hours he battled with his quarry and finally brought it to gaff.

Wherever fishermen foregathered in that day, the story of Jones' triumph was told and soon Indian River Inlet became the mecca of the Nation's rod and reel champions. Today tarpon fishing is an established sport at many resorts in southern Florida, especially from May through July, both on the Gulf side and in the Atlantic, and clubs strictly regulate the character of tackle to be used to a point where only skill can win a tournament prize.

Real sportsmen seldom kill these "fighting fools" of the deep; instead they, as true gentlemen should when victors, use no gaff and release the tired battler when he is finally brought alongside.

The vast schools of mullet upon which the tarpon preys form the magnet that draws him to the various feeding grounds in Gulf and Florida waters.

Ordinarily one does not think of the weakfish, or squeteague, as offering much in the way of sport, but when angled for with appropriate tackle it can give the fisherman thrills that leave little to be desired.

Its abundance and willingness to bite make it popular with anglers who want action. It is a handsome member of the



Photograph by Christian W. Feigenspan

IT IS EASIER TO TOW AN 800-POUNDER THAN LAND HIM

When a giant North Atlantic tuna is captured with rod and line, there is a battle to bring him to boat. No sport requires more skill and endurance than fishing for these magnificent fighters.

finny tribe. The Cape Cod fishermen and those in southern areas call it the "drummer" because of the peculiar noise it makes when traveling in schools. It gets its name "weakfish" not because of its lack either of gameness or stamina but because the bony processes of its mouth are soft and tender.

There is never a doubt when a weakfish bites. It simply swoops down on the bait and is off with it like a flash. Its soft mouthparts call for skill in bringing it in. A sudden jerk will tear out the hook; therefore the line must always be properly taut and the fish must be led in rather than dragged. Rods weighing from ten to fifteen ounces, made of greenheart or bamboo, are prescribed for weakfish angling, and a fine



© Ewing Galloway

BUYERS MATCH FINGERS IN THE DIVISION OF BARRELS OF FISH

"Mora," as the practice is called, is a very old Italian game. It is played either for wagers or for fun and the Italians are skillful at it. Shore haddock, landed only a few hours after being caught, enjoy an eager demand at twice the price of offshore haddock.

linen line 300 feet long, with a multiplying reel, is employed.

All anglers agree that the fisherman who hooks a striped bass with sportsmanlike tackle has a run for his money. Once hooked, this flashing, silver, streamlined fighter does not spend its time leaping out of the water, trying to shake the line loose, as does the salmon.

THE STRIPED BASS IS A SCRAPPER

Rather it makes a first fierce plunge and brings every ounce of its muscular fiber to bear against the line. If this is strong enough to hold it in leash, it seeks to free itself by finesse and strategy. Now it tries to chafe the line over the sharp edge of the rocks to which it runs; failing in that, the fighter will attempt to foul the line in seaweed and kelp.

Loving brackish water, the striped bass brings the sport of philosophers a considerable distance inland. Roanoke and Potomac rivers near their mouths, the Chesapeake Bay area, the Raritan and the Passaic, and numerous others afford excellent fishing grounds for striped bass. It is a temperamental fish, shy to a degree

at times, now taking one bait and now responding to another. Small eels, shrimps, crabs, and bloodworms are evidently to its particular liking.

Usually we think of the bluefish as one of the dependables of the bill of fare; but it has some exciting moments to offer the angler who prefers the rod and reel of the sportsman to the hand line of the pot fisherman.

With a spanking breeze and a moderate sea, the man who hooks a bluefish earns his dinner. It makes a smashing fight and the fisherman who lacks the skill of giving proper tautness to his line is likely to find it broken by a sudden rush or shaken loose if allowed to slack.

BLUEFISH MAY BITE A LINE IN TWO

Though the leader may be of wire, the fish will attempt to swim ahead and often bites the line in two with its sharp teeth.

It is related that bluefishes are utterly wanton in their gluttony and will prey on a school of lesser fish until their stomachs are so full that they disgorge the harvest and begin all over again.

The bluefish, like the striped bass, brings the joy of salt-water game fishing into the



Photograph by Wide World

NEPTUNE HIMSELF MIGHT RIDE SUCH A STEED

Largest sturgeon ever caught in the North Sea, this giant weighed a little short of 1,000 pounds. It was placed on display in London. Not highly regarded during earlier years, the flesh of the sturgeon has gained in favor recently. Like the salmon, shad, and alewife, the species ascends the larger rivers to spawn. A clumsy, bottom-feeding fish, it is easily netted.

mouths of many of the Atlantic coast rivers, notably the Hudson, the lower Potomac, and Chesapeake Bay.

Some of the deep-water food fishes offer good sport for the fishermen who go down to the sea in boats to cast their lines. One of these is the sea bass, a rather sluggish citizen of the sea, but withal a ready biter and interesting game for those who like to go out on an excursion steamer that drops anchor, for instance, on the banks off Sandy Hook or Atlantic City.

THE SEA BASS LEAPS VICIOUSLY

Sometimes the sea bass breaks water like its river cousin and makes vicious leaps and contortions in its efforts to free itself; but its jaws are leathery and once well hooked it seldom gets away.

All hands pay tribute to the kingfish as one of the gamest for its size of all the bottom-feeding denizens of salt water. Famous alike for its qualities, its splendid color, its graceful form, and its fine flavor, it was christened the kingfish by the *bons vivants* of Colonial days when New York was yet New Amsterdam. It takes bait

readily, clams, bits of fish, shedder crabs, sandworms, and shrimps being to its liking. Many surf fishermen think the best time to catch kingfish is the first of the flood tide.

Very recently sportsmen have discovered excellent summer hunting grounds for taking big marlin, tuna, and other oversize battlers that challenge the skill of real deep sea fishing enthusiasts. These prolific areas, ranging from ten to thirty miles off-shore, can be reached in good charter boats from Ocean City, Maryland, Atlantic City, New Jersey, and other convenient coastal places along the Middle Atlantic States.

The treasures of the sea are many, but none is more certain to yield delight to the true sportsman than the game fishes that disport in its waters. The commercial fisherman, with his seines and hand lines, is perennially harvesting boatloads of sea fish for a large consuming public. But there is a real joy of the ocean for those with rods and lines designed to put the fisherman and his prize on even terms—something like the fair handicap in golf—where human skill meets piscatorial generalship and the issue is in doubt to the climax.

Pollock

(*Pollachius virens*)

Usual Length, 24 to 36 Inches

The pollock, also called green cod, or coal-fish, has a range that includes both sides of the Atlantic, reaching our shores as far south as Cape Henry, although it is not taken in commercial quantities south of New Jersey. In size it attains a weight of more than 40 pounds and a length of 4 feet. It is a voracious eater and very destructive of young cod.

Though a bottom-feeder, the pollock also frequents the surface and intermediate depths. It congregates in large schools, roams from place to place, and preys on all kinds of young fish.

Professor Sars tells of witnessing an attack by a band of pollock on a school of small cod. The latter were completely surrounded and driven into a compact mass. On the edge of the mass the pollock bored in, wolfing their way, while from above the screeching sea gulls plunged down to share the feast.

In dire panic the young cod darted this way and that, breaking through the line as best they could. It was a veritable massacre.

The pollock appear about Cape Cod early in May, passing Race Point so close inshore that they are often caught with seines on the "tide rips." A favorite spawning ground is off Cape Ann, where they stay from early May to late January.

Cod

(*Gadus morrhua*)

Usual Length, 28 to 36 Inches

The codfish belongs to a family which comprises many species, including some of our most valuable marine fishes. The principal species are the cod, haddock, pollock, hake, and cusk.

The cod owes its value as a food fish to its flavor, size, comparatively few bones, year-round abundance, and adaptability to dry-salting. Fishes rich in oil cannot be successfully dry-salted, and for this reason such species as the salmon, bluefish, and mackerel, if salted at all, must be put into brine.

The cod is a cold-water fish and its movements are largely governed by changes in the water temperature. However, the temperature in many parts of the North Atlantic is so low throughout the year that the codfish may be caught in equal abundance the year round. It is generally taken at depths of from 8 to 40 fathoms, but is known to inhabit much deeper water. It is found on our Atlantic coast from Cape Hatteras northward and is also an important species on the European coast. It is taken in commercial quantities in all our Atlantic States from New Jersey northward.

The cod is taken with otter trawls, trawl lines, hand lines, and gill nets. The larger vessels employ the otter trawls and are known

as "trawlers." Hand lines and trawl lines are the most popular methods of fishing, as their use requires only a small boat and crew.

The cod is an omnivorous feeder, eating almost anything it happens upon. Its chief food appears to be mollusks, crustaceans, worms, and fish, but articles such as jewelry, glass, stones, leather, etc., have been found in its stomach. Its omnivorous habit is responsible for the finding in its stomach of rare fishes and shells that otherwise might not have been known to exist.

Spawning takes place along the New England coast from October to June. The eggs are about one-nineteenth of an inch in diameter and since they float at the surface, many are cast ashore, eaten by birds, or otherwise destroyed. To offset this great destruction, Nature has rendered the cod very prolific and a good-sized fish may contain several million eggs.

The largest cod recorded was more than 6 feet long and weighed $211\frac{1}{4}$ pounds, but fish weighing more than 75 pounds are comparatively rare. The usual size of those taken on the banks ranges between 10 and 35 pounds. The cod is not a game fish, but when hooked by an angler is a welcome addition to his catch.

It is said that the cod fisheries constituted one of the inducements that led England to establish colonies in America. Their early importance was so great that the cod won a place on the seal of the Colony of Massachusetts, and in the Massachusetts State House it is honored with an image.

Haddock

(*Melanogrammus aeglefinus*)

Usual Length, 23 to 30 Inches

The haddock is close to the cod both in appearance and in its quality as food. It may be known at sight by the characteristic black lateral line that reaches from gill to tail. The "Finnan Haddie" of commerce, which is said to take its name from Findon or Findhorn, both towns in Scotland, is smoked haddock. Unlike the cod, the haddock is seldom salted.

On the American coast the haddock rarely is encountered north of the Straits of Belle Isle or south of Hatteras. On European shores its habitat extends from Icelandic waters to those of France and entirely surrounds the British Isles.

More gregarious than the cod, the haddock swims in large, compact schools in its migrations from place to place. It is a bottom-feeder and has marine invertebrates for its principal diet, mollusks seeming to be favored above everything else. The spawning season of the haddock is from April to June. The average size of those caught is from 2 to 4 pounds, with 17 pounds as about the maximum.

Among food fishes of the Atlantic, the haddock has a big lead in volume of annual catch, with 172,000,000 pounds in 1937.



Hashime Murayama

Painting by Hashime Murayama

AMONG FOOD FISHES OF THE ATLANTIC, HADDOCK AND COD RANK FIRST AND SECOND IN QUANTITY AND ALSO HIGH IN VALUE

A cold-water fish of great abundance, the **Cod** (center) is found on our Atlantic coast from Cape Hatteras northward and is also an important species of European shores. The catch of **Haddock** (bottom fish) has exceeded even that of cod during all the years from 1919 to the present. Ranging across the Atlantic and as far south as Cape Henry, the **Pollock** (at top) attains a weight of more than 40 pounds and a length of four feet.

Winter Flounder

(*Pseudopleuronectes americanus*)

Usual Length, 15 to 17 Inches

The winter flounder inhabits shallow water and occurs along the coast from northern Labrador southward at least as far as Cape Lookout. In the southern part of its range it is found only during the winter. At Cape Lookout it is taken in small numbers only during exceptionally cold winters. In Chesapeake Bay, though absent during the summer, it is an important food fish during the winter, when almost all other species sought commercially are missing.

The most remarkable feature of the flatfishes is their flatness. Somewhat less obvious at first is that they swim and rest on one side, some species on the right and others on the left side, and both eyes are on one side of the head.

The young start life quite "normally," for at first they swim in an upright position, and, like most other fishes, have one eye on each side of the head. However, very early in life they begin to rest either on the right or the left side, and the eye that happens to be on the lower or downward side of the head begins to "migrate" to the upper side. This surely seems to be a wise provision by Nature. Of what value would an eye be turned toward the ground and away from the light? In the smaller species studied the migration is completed before the young fish reach a length of one inch.

The winter flounder almost invariably rests on its left side, which causes the right side to become pigmented, whereas the other side, being away from the light, and generally on the bottom, remains pale. Because this fish rests on the left side, it is the left eye that migrates to the upper, or right, side of the head.

The winter flounder of necessity is limited to prey of small size because of its small mouth. Many different kinds of small crustaceans, mollusks, worms, small fish, and other marine animals have been found among its food.

The meat of this fish is of good flavor, and the demand is increasing steadily. Flounders usually are not separated by species for the market. It is estimated, however, that the catch of the winter flounder in the New England States alone probably exceeds 25,000,000 pounds. The fish are caught in seines, in otter trawls, and in several kinds of trapnets. It is also taken by anglers, for it is one of the few shore fishes that can be caught in northern waters during late winter.

The winter flounder spawns from about January to May, according to locality, the spawn maturing earlier southward than northward. At Cape Cod, for example, the spawning season is at its height in February, but in Maine the season is about two months later.

The eggs are cast on sandy bottom in shallow water, and, being heavier than seawater, they sink to the bottom, generally in clusters. They are only about three-fourths of a millimeter in diameter, and require from 15 to 18 days to hatch in the usually prevailing water temperature of about 37° F. It has been estimated that a large female produces as many as a million eggs during one spawning season.

Summer Flounder

(*Paralichthys dentatus*)

Usual Length, 15 to 20 Inches

This flounder lives in the shallow shore waters all the way from Cape Cod to South Carolina and probably to Florida, being most numerous, however, from New York to North Carolina. It frequents both sandy and muddy bottom, and often is taken in muddy estuaries where the water is only moderately brackish.

The summer flounder has its eyes and color on the left side, whereas the winter flounder has them on the right side. It is so exceedingly rare that an individual makes the "mistake" of turning in the opposite direction that turning left may be said to be an invariable rule.

This fish is remarkable for its ability to mimic or to simulate the color and pattern of the ground upon which it lives. If placed on a red background, it becomes red; on blue it turns blue; on green it becomes green, and so on through all colors or shades one may care to use in the bottom of an aquarium. Furthermore, it not only simulates the color of the ground upon which it lives, but it also mimics the pattern.

The summer flounder has a larger mouth than the winter flounder, and accordingly is capable of taking larger prey. It seems to be chiefly a fish eater, though squids, shrimps, crabs and other forms of animal life of suitable size also are taken.

Although the flesh of this flounder is rather dry, it has a good flavor, brought out best when baked. It is estimated that more than 6,000,000 pounds are caught annually.

It is taken with seines, pound nets, otter trawls, and also with hook and line. Because it has a larger mouth, consequently being able to take larger bait, and because it grows larger, and wages a harder fight than the winter flounder, it is a better sport fish. Though the usual length of fish seen in the markets is only about 15 to 20 inches, 24-inch fish are not rare, and giants three feet long and weighing 25 pounds have been reported.

This species, like the winter flounder, spawns in the winter. In North Carolina spawning appears to begin as early as September and may continue until April or May. Few fish with ripening roe have been seen, and the eggs remain unknown, the duration of spawning having been determined from the presence of larvae in the tow.



Painting by Hashime Murayama

WHILE STILL VERY YOUNG, A FLOUNDER TURNS ON ITS SIDE AND THE DOWNWARD EYE "MIGRATES" TO THE TOP

When newly hatched, flounders swim upright like most fishes. The **Winter Flounder** (upper left) ranges from northern Labrador southward at least as far as Cape Lookout, abounding particularly along the New England coast. Found from Cape Cod to South Carolina, the **Summer Flounder** (center) like the winter species, frequents the ocean bottom, where it is effectively camouflaged by its shape, color, and habit of partly covering itself with sand

Halibut

(*Hippoglossus hippoglossus*)

Usual Length, 4 to 6 Feet

The halibut is the largest fish of the flounder family. Only a few fishes, such as the largest sharks, swordfish, tuna, and sturgeon, exceed it in size. Though "large" halibut landed in New England ports range in length from only about four feet to six feet, and in weight from 50 to 200 pounds, some weighing 300 and 400 pounds are taken. A nine-foot-two-inch giant, weighing 625 pounds when dressed, was caught 50 miles off Thatcher Island, Massachusetts, in 1917.

The halibut is a cold water fish inhabiting all northern seas, ranging southward on the European coast to France, on the Atlantic coast of America to New Jersey, and on the Pacific coast to northern California. In making the foregoing statement the writer is regarding halibut from all waters as of one species, though he is aware that the "stocks" from different regions vary considerably and that attempts have been made to split them into several species.

This large and useful food fish has diminished in abundance so alarmingly that drastic measures seem necessary to preserve the fishery. Although formerly a shallow water fish, it is now classed as of deep water for it is at present most numerous in water 100 fathoms or more deep. This is not the case because the fish has changed its habitat, but apparently because the stock that formerly inhabited the shallow water has virtually been exterminated.

The "new" distribution indicates that the halibut population consists of "stocks" that do not migrate from deep to shallow water, but stay more or less in a limited region. Since the shallow water stock on the New England coast and elsewhere has been almost exterminated, it apparently will be very difficult to effect a recovery.

The decline on the Pacific coast has been equally as pronounced. It became so alarming that the United States and Canada set up the International Fisheries Commission largely to study the life history of the halibut and the fishery and to recommend adequate conservation methods. Perhaps one of the most important measures that has resulted is the closing of certain halibut fishing banks until they become restocked.

The halibut, like the winter flounder, has the eyes and color on the right side. In this large fish the left eye does not complete its "migration over the head" until the animal has attained a length of close to two inches. In this migration the eye carries its socket with it. In fact, the whole skull is twisted.

The halibut is very voracious, feeding chiefly on fish. To name all of the species that have been found in halibut stomachs would make a long list. Among them are cod, haddock, mackerel, flounders of several kinds, herrings, cusk,

rosefish, hake, sculpins, grenadiers, and skates. Crabs, lobsters, clams, and mussels also are eaten. Even seabirds occasionally are taken, as well as refuse from vessels. Fishermen have found indigestible articles, such as pieces of iron and wood, and even a piece of drift ice in halibut stomachs.

The age of halibut may be determined from a study of the otoliths, or earstones. A European investigator has determined that in the vicinity of Iceland fish one year old range from 3.1 to 5.9 inches in length. At five years of age they were 16.1 to 28 inches long, and at ten years 29.5 to 55.5 inches. The wide range in length of fish of these different ages indicates very unequal growth, which is not unusual among fishes. It has often been said that fish live to eat, an assertion that is not without foundation; for it is a fact that nearly all fish grow fast, environmental conditions being correct, if they are able to get plenty of nourishing food. On the other hand, a fish will survive a long fast, but of course it does not grow if it does not feed. The figures on the rate of growth seem to show also that the very large halibut, weighing 300 pounds and more, probably have attained a high age.

Statistics showing the world catch of halibut are not at hand. However, nearly 3,000,000 pounds are still marketed annually in New England, and nearly 25,000,000 pounds in the Pacific coast States. The fish are taken principally with trawls.

Contrary to what one might expect, very little was known about the breeding habits and the early life of this common and important foodfish until very recently when the investigators of the International Fisheries Commission succeeded in finding the eggs and larvae on the Pacific coast of America. It is believed to spawn in February in Iceland and Europe. On the New England coast it apparently continues to spawn throughout spring and summer, as shown by ripe fish taken, for naturally spawned eggs have not been reported from there. On the Pacific coast of North America the eggs and larvae have been taken from December to June.

It was thought for a long time that the halibut spawned only in great depths, but more recent investigations seem to show that some spawning may take place in rather shallow water.

The eggs are very large, as compared with most other marine fish eggs, averaging about 3.25 millimeters in diameter. They are rather heavier than seawater, and although they do not sink to the bottom, neither do they float at the surface, but occur at intermediate levels.

The newly hatched larvae also live at intermediate depths, though rather lower than the eggs. Later they rise to the surface layer, but at the age of about six or seven months they settle down on the bottom where they remain most of the time the rest of their lives.



Painting by Hashime Murayama

TO ESCAPE FOES AND SURPRISE PREY, THE HALIBUT BURIES ITS FLAT FORM IN SAND

Largest of the flounder family, the **Halibut** inhabits all northern seas. It is found on both the Atlantic and Pacific coasts of the United States as far south as New Jersey and northern California. It is generally, but not always, true that flatfish frequenting cold water have eyes and color on the right side whereas species in warmer seas "wear" them on the left. The halibut is at present most numerous in water 100 fathoms or more deep.

Sturgeon

(*Acipenser sturio*)

Usual Length, 6 to 9 Feet

The common Atlantic sturgeon is among the largest fishes, being exceeded in length only by the largest sharks and probably by an Eurasian relative. Individuals 18 feet long were reported many years ago both from Europe and America. The authenticity of these old records cannot now be confirmed. Today the maximum length of American fish is more nearly 12 feet, with females 7 to 9 feet long not uncommon. Males run considerably smaller in size, and rarely exceed a length of seven feet. A 10-foot fish, if in good condition, weighs about 500 pounds.

This sturgeon has a single rare and much smaller relative on our Atlantic coast, two on the Pacific coast, and several in fresh water.

If the Atlantic sturgeons of America and of Europe are considered identical (concerning this there is some doubt), the general range of distribution extends from Scandinavia to the Mediterranean Sea on the coast of Europe, and from the St. Lawrence River to the Gulf of Mexico on the American coast. The fish was once reported from Hudson Bay, but it probably does not occur there regularly.

This sturgeon, like the salmon, the shad, and alewives, is anadromous. That is, it spends most of its life and makes most of its growth in the sea, bays, and estuaries, and ascends the larger rivers to spawn. During winter it disappears from the shallower waters, either migrating southward, or more probably offshore to deep water. In the bays and sounds of North Carolina and in Chesapeake Bay it is expected to return in April, and northward somewhat later in the spring.

Sturgeons are easily distinguished from other saltwater fishes by the bony head, by the several rows of bony shields or bucklers along the side, by the sharklike tail, and by the small suction mouth, placed under the head far behind the tip of the long, flat, shovel-like snout.

Because of its small mouth, which possesses no teeth, this large fish always must feed on comparatively small organisms. These it finds on or in the bottom of the waters, in which it lives, and they include both plants and animals. This fish has been defined as a "mud grubber," rooting in the sand and mud with its snout like a pig, digging up worms and mollusks. Small fish also are included in its diet. After it enters fresh water, it feeds little or not at all, being intent then only on carrying out the reproductive processes.

The flesh of the sturgeon was not highly regarded during the early days of this nation, but it has gained in favor so greatly in recent years that it has sometimes retailed when fresh at as much as 50 cents a pound. With caviar

selling at as much as \$3.50 a pound, it is evident that a single large female containing caviar roe is worth several hundred dollars.

This sturgeon formerly was much more numerous than now. Sturgeons are clumsy animals and are easily netted, and because of their comparatively great value they are extensively sought. Furthermore, many of the rivers they ascend, or formerly ascended, are badly polluted, and thus unfit for the development of the eggs and young; and more than a few streams are obstructed with dams making ascent impossible. All these factors have contributed to their steady decline, which in some areas amounts to commercial, if not absolute, extinction.

The total catch of sturgeon for the Atlantic coast of the United States, according to U. S. Bureau of Fisheries statistics for 1935, was only 155,000 pounds, valued at about \$15,000. But caviar, made from sturgeon roe, amounted to 149,000 pounds, valued at \$426,000. In recent years, most of our sturgeon caviar has been imported from Russia.

In New England, where the first sturgeon fishery was established, away back in 1628, only 5000 pounds were marketed in 1935, a drop from 20,000 pounds as recently as 1919. In Chesapeake Bay, where the catch amounted to 900,000 pounds in 1890, it had dropped to about 22,000 pounds in 1920. Though the annual catch has fluctuated considerably, the trend in general has been somewhat upward for Chesapeake Bay since that time.

The roe must be green, or unripe, to make caviar. The eggs are removed from the fish and gently rubbed over a fine screen to separate them from their enveloping membrane. Under the screen the released eggs fall into a trough, through which they pass into tubs. In these tubs salt is carefully stirred with the eggs, and it draws water from them and forms a copious brine. Later the eggs are poured into fine-meshed sieves and allowed to drain until dry. They are then put into casks or cans.

The sturgeon spawns in the spring in the larger rivers along the Atlantic coast. It is very prolific, and one large female may produce from 1,000,000 to 2,500,000 eggs in one season. The weight of the roe may constitute one-fourth of the total weight of the fish, and amount to as much as 5 to 15 gallons in bulk.

The eggs are fairly large, measuring about 2.6 millimeters in diameter. They are demersal, that is, heavier than the water in which they are spawned. They are adhesive, and as they sink in the water they become attached to brush, weeds, stones and other objects. They hatch in about a week at a temperature of 64° F.

The newly hatched larvae are about 11 millimeters long. In only a few days they increase to a length of about 18 millimeters. Sexual maturity supposedly is reached when a length of about four feet is attained.



Hashime Murayama

Painting by Hashime Murayama

OVER-FISHED FOR ITS PRECIOUS CAVIAR, THE STURGEON IS ALMOST A COMMERCIAL "HAS-BEEN."

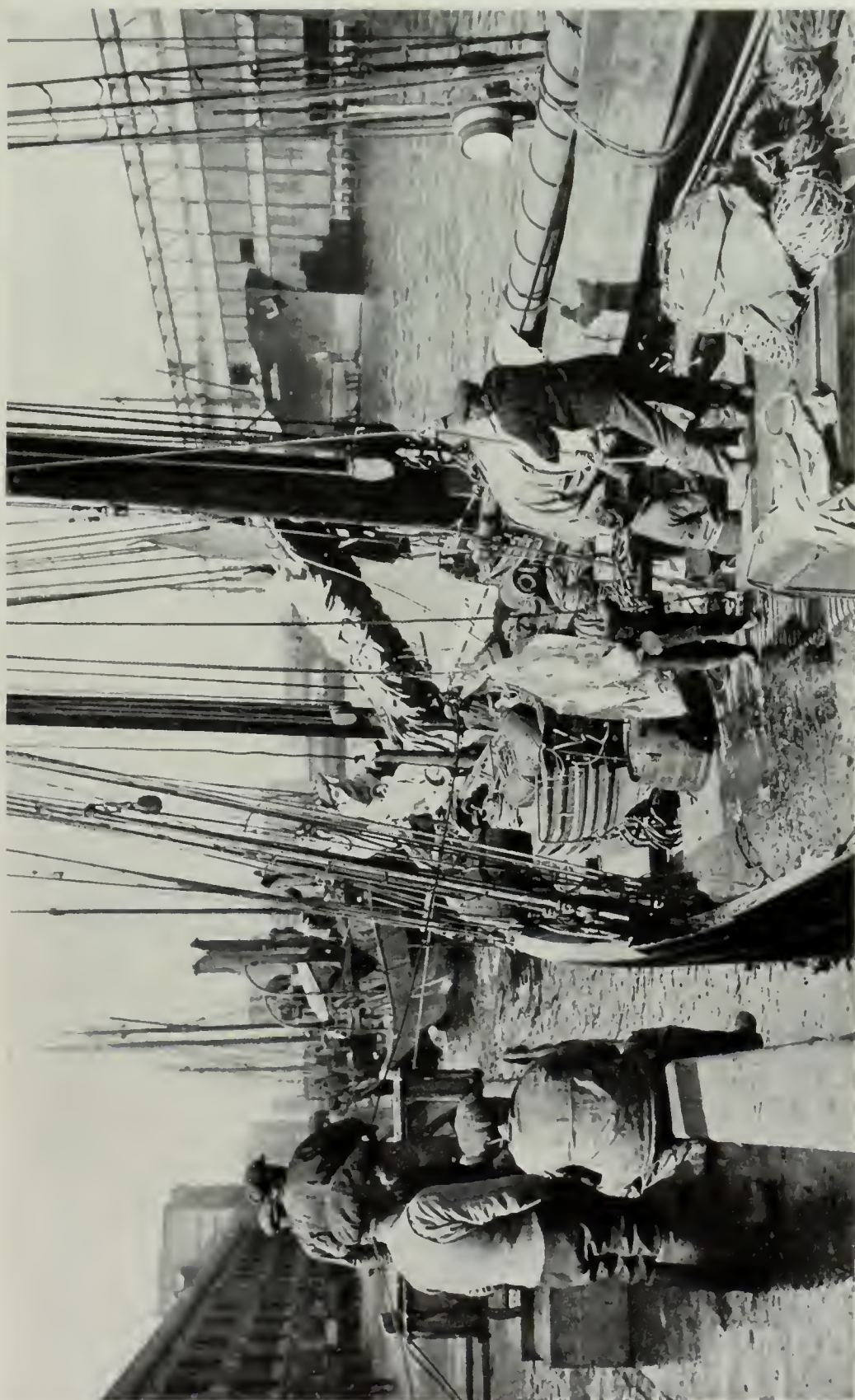
Catches of the **Sturgeon** are now trifling compared with the heavy annual hauls of this fish made at the end of the last century. On the American coast its range is from the St. Lawrence River to the Gulf of Mexico, with Chesapeake Bay a center of comparative abundance. It may reach a length of 12 feet and is anadromous, living mostly in the sea but ascending fresh-water rivers to spawn. Commercial caviar is made from the abundant roe of the female



Photograph by H. Armstrong Roberts

DOBBIN HELPS HAUL NETS DOWN TO THE SEA

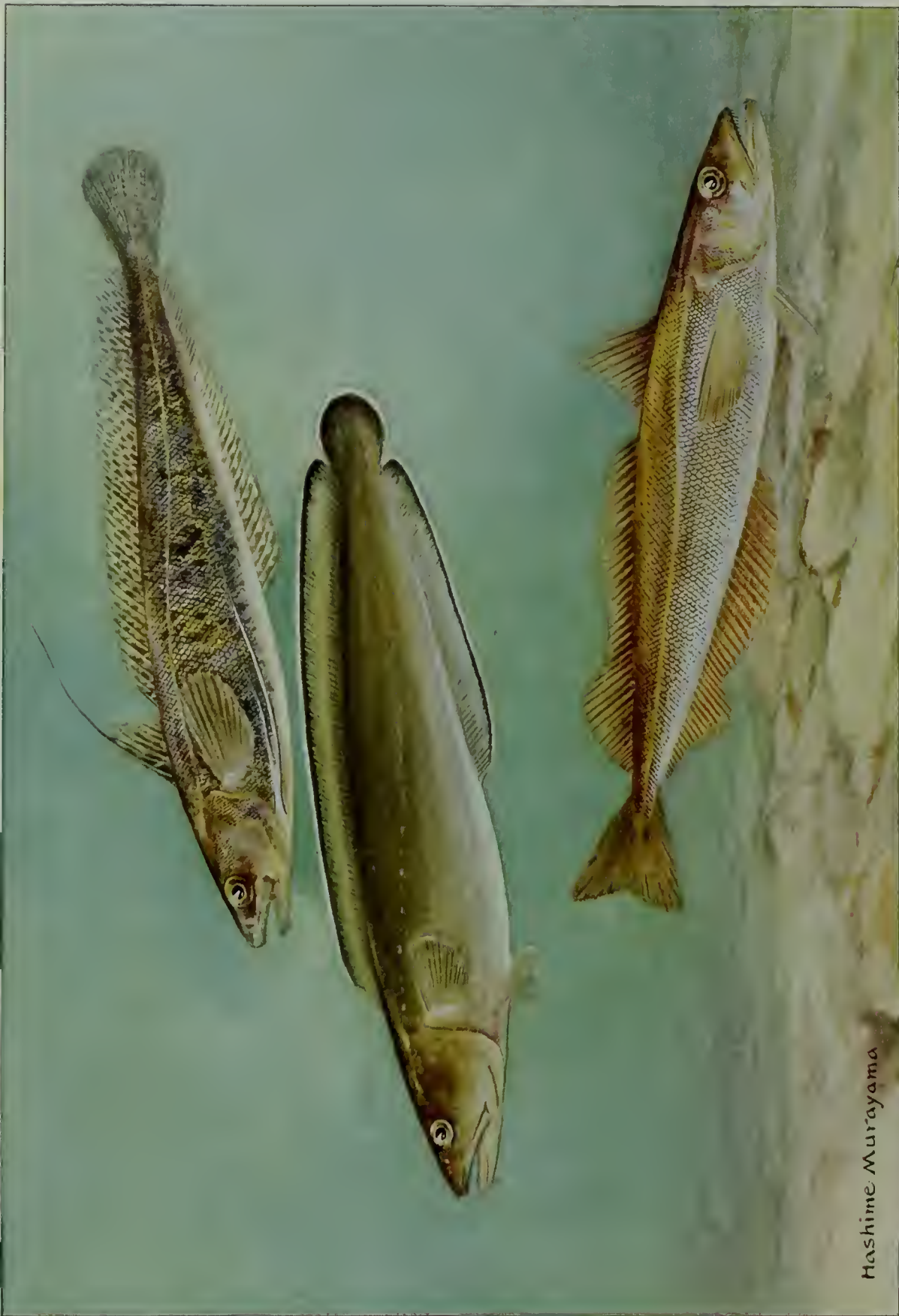
Though the total fish crop of the United States, according to 1937 figures, amounts to almost four-and-a-half billion pounds, we probably eat less fish per person than any other country of the world—only 13.3 pounds a year per capita as against 55 pounds in Japan, 52 in Sweden, 44 in Norway, 39 in Denmark, 37 in Portugal, and 35 in England and Wales. The U. S. Bureau of Fisheries performs an invaluable service, not only in inducing the public to eat more fish, but also in popularizing new species.



© Ewing Galloway

HALIBUT AS LONG AS MEN COME ASHORE AT BOSTON

It takes two stalwarts hauling on a block-and-tackle to lift out the big flatfish. In the Gulf of Maine, the halibut has been seriously depleted by overfishing, but fortunately it has been discovered in such abundance along the deeper slopes of the Banks that a continued supply is assured. New England halibut fishermen have operated for years in the neighborhood of isolated Sable Island.



Hashime Murayama

Painting by Hashime Murayama

THREE COMMON FISHES OF NEW ENGLAND WATERS ARE ALL VALUABLE AS FOOD FOR MAN

Both the **Squirrel Hake** (top) and the **Cusk** (center) belong to the cod family. They are bottom feeders, the former preferring sand and mud banks, while the latter is taken chiefly on rough, rocky ocean floor. The squirrel hake ranges from the Gulf of St. Lawrence to North Carolina, while the cusk occurs from the Arctic to New Jersey. The **Whiting** or **silver hake** (bottom fish) is found in deep, cold waters from Newfoundland to the Bahamas.

Squirrel Hake*(Urophycis chuss)*

Usual Length, 15 to 20 inches

The squirrel hake has six near relatives on the Atlantic coast of America, and several others somewhat more distantly related, all belonging to the very numerous codfish family. Neither the largest nor the smallest of its group, it seldom exceeds a length of 30 inches, and fish exceeding 25 inches are rare; whereas its nearest relative, the white hake (*Urophycis tenuis*) reaches a length of 42 inches. On the other hand its southern relative (*Urophycis floridanus*) is too small to be of much commercial value, since it seems to attain a length of only about eight inches.

This hake ranges from the Gulf of St. Lawrence to North Carolina. It is strictly a bottom fish and is found both on sand and mud, all the way from tide mark to a depth of about 300 fathoms.

This species, according to the stomach contents of fish taken in Chesapeake Bay, feeds principally on shrimps. However, squids, amphipods and small fish of many species have been found in the stomachs of fish taken at Woods Hole, Massachusetts. One of its favorite foods is the sand lance. An investigator has reported that he saw hakes caught off Sandy Hook, N. J., so gorged that the tails of launces eaten projected from their mouths because the stomachs were too full to receive them.

Though the meat is soft, it has good flavor and the catch is readily absorbed. Since the hakes are not separated by species in the market, the statistics for any one species cannot be given. The total catch of "hake" for New England listed in the statistical reports of the U. S. Bureau of Fisheries for 1935 was 26,541,000 pounds.

The squirrel hake spawns from late spring to autumn. The extremes of the spawning season, which is a long one, have not been determined. In the Massachusetts Bay region spawning is most actively under way during early summer.

The eggs of this fish are very small, averaging only about 0.74 millimeter in diameter. They are clear and buoyant, floating at the immediate surface, and are well provided with oil droplets. The incubation period is short, the eggs hatching in somewhat less than four days in a water temperature of 60° F.

The newly hatched fish is a tiny, helpless creature, only 1.83 to 1.98 millimeters long. It floats on its back at the surface for several days, when it is subject to being carried here and there by winds, currents, and tides. When it rights itself, it is ready to feed. The rate of growth seems to be fairly rapid, a length of one to three inches apparently being attained the first summer, 7.9 to 8.3 inches at one year of age, 13 to 14 inches at two years.

Cusk*(Brosme brosme)*

Usual Length, 18 to 24 inches

Another member of the numerous family of codfishes, the cusk resembles the squirrel hake in the form of the body, but differs from them in having only one, instead of two fins on the back. Furthermore, the pelvic fins, which consist of two slender filaments in the hake, have five short rays in the cusk.

This cusk, which is strictly a bottom-dwelling fish, occurs in the Arctic polar region and ranges south on the American coast regularly to Cape Cod and occasionally to New Jersey. It is an offshore fish, rarely taken in less than 10 to 15 fathoms. Off the New England coast it is seldom taken at a depth exceeding 100 fathoms, presumably because the bottom is not suitable, for the species has been reported from 500 fathoms in European seas. The cusk is taken chiefly on rough bottom where there are rocks, ledges, and gravel, and occasionally on mud with hake.

The food of the cusk consists of crustacea and small mollusks. It is not at all fastidious as to bait, readily accepting clams, cockles, and herring.

Spawning occurs in the spring. The cusk is among the most prolific fish, and a medium-sized female may deposit as many as 2,000,000 eggs in one season. The eggs are buoyant, as in the other cods, and are only about 1.3 to 1.5 millimeters in diameter. The larvae are 4.0 millimeters long at hatching. The young cusk lives at the surface until it is about two inches long, when it descends to the bottom in considerable depths.

Whiting*(Merluccius bilinearis)*

Usual Length, 12 to 20 inches

The whiting, also sometimes known as the silver hake, formerly was placed in the codfish family, but ichthyologists now regard it sufficiently different to require, with certain near relatives, a separate family. Contrary to the codfishes, it has no barbel or whisker at the chin. Its pelvic fins are not long and filamentous as in the hakes, but of ordinary form.

The range of the whiting extends from Newfoundland to the Bahama Islands, but it is most common between Cape Sable and Cape Cod. In New England it is taken from the shore line to a depth of about 300 fathoms. Southward, as in the vicinity of the Bahama Islands, it is found only in deep, cold water.

The food of this fish consists chiefly of fish of suitable size, and of squids, crabs, and other crustaceans.

Spawning takes place from June to October. The eggs float at the surface. The young fish are pelagic, but go to the bottom when an inch to an inch and a half long.



Hashime Murayama

Painting by Hashime Murayama

FRESH, SMOKED, OR SALTED, THE MACKEREL IS ONE OF OUR MOST FAMILIAR MARKET SPECIES

The **Mackerel** is a member of the family of the same name, which includes also the tuna, the bonito, the kingfishes, the Spanish mackerel, and the wahoo. Ranging between Cape Hatteras and the Straits of Belle Isle, it appears to migrate from south to north in the spring, or, perhaps, from deep water inshore. The mackerel spawns from about May to July, the fish generally coming to the surface for the event.

Mackerel

(*Scomber scombrus*)

Usual Length, 12 to 16 Inches

The mackerel is a member of the family of the same name, which includes also the tuna, the bonito, the kingfishes, the Spanish mackerel, and the wahoo. Shaped more or less like a cigar, the body of the mackerel is very muscular. Consequently it is adapted to great speed. A maximum length of 22 inches is attained, and a length of 18 inches is not exceptional. A mackerel a foot long weighs 12 to 16 ounces, and one 20 inches long weighs between three and four pounds.

This species, often called the northern mackerel to distinguish it from the southern or Spanish mackerel, inhabits both coasts of the North Atlantic. On the European coast it ranges southward to Spain, and on the American coast to Cape Lookout. It does not occur in commercial abundance, however, south of Virginia. Although the mackerel can scarcely be classed as a shore species, it is not taken very far out at sea.

The mackerel congregate in schools, some of which comprise a great number of fish, schools 20 miles long and a half mile wide having been sighted. By actual measurement it has been found that the fish in a school do not vary more than an inch in length, a fact indicating that they are all of the same age. The schools are seen only when the fish come to the surface, where they do not always remain. Possibly they are guided in their movements by the particular depth that offers the most food and the most comfortable temperature.

The fact that mackerel appear near the shore earlier in the spring in the southern parts of their range than northward may indicate a southward migration in the autumn and a northward one in the spring. It has also been suggested that the migration may be offshore to deep water. The presence of a few mackerel in cod stomachs taken in deep water during the winter, as well as the capture of an occasional specimen in those waters during cold weather, lends support to the latter theory. In the light of present day knowledge it seems correct to say that both theories are right in a measure, but that the main winter home of the mackerel still remains unknown.

No other important commercial fish has fluctuated so much in abundance as the mackerel. The fishery has yielded as high as 120,000,000 pounds (in 1884) and two years later declined to a mere 20,000,000 pounds. In 1910 the catch reached an all-time low of only 4,000,000 pounds, but in 1926 it was up to 46,000,000 pounds. In 1922 the total catch for the United States was only 8,798,000 pounds. The following year the catch came up to 23,391,000 pounds, presumably without much if any increase in fishing effort. Recent investigations have shown that fluctuations are caused

in large part by good and bad spawning years.

The two important factors in any spawning season no doubt are temperature and food for the young fish. However, the necessary abundance of micro-organisms, upon which the young feed, quite surely also depends on the temperature to a considerable extent, and probably to some extent on sunshine, winds and currents. It may be said, then, that if weather conditions are correct a good hatch and a high rate of survival may be expected for such a season.

Recently an investigator found that mackerel, which were supposed to be unable to live in aquaria, will live in confinement, provided a very long tank is used. Apparently the mackerel is so accustomed to fast swimming that its gills will not function properly unless there is a considerable rush of water over them.

The food of the mackerel throughout life consists of free swimming organisms, chiefly small animals. The large fish take larger food than the small ones, yet nothing much larger than fish fry is taken. The diet includes copepods, small shrimps, molluscan larvae, annelids, squids, fish eggs, and small fish. In short, practically all small floating animals, except medusae and ctenophores, are included.

The total catch for the New England States in 1935 was 61,950,000 pounds. South of New England the catch by comparison was insignificant, amounting to only about 3,000,000 pounds. The fish are caught principally with purse seines, with drifting gill nets, and with pound nets, weirs and traps, and to a limited extent with lines.

Spawning occurs from about May to July. When the fish are ready to spawn, they come to the surface. The mackerel has no particular breeding ground. The fish merely cast their eggs wherever their wandering habits have chanced to lead them when the sexual products are ripe. Thus, the eggs generally occur over a wide area.

The mackerel is moderately prolific, females of medium size producing 360,000 to 450,000 eggs. The eggs are buoyant, and are from 1.1 to 1.2 millimeters in diameter. Incubation occupies about four days at a temperature of 60° to 62° F. The newly hatched fish are 3.1 to 3.3 millimeters long. The rate of growth is rapid. Fish seven inches long in the fall of the year in which they were hatched have been reported; and when a year old, or at least only in their second summer, they already enter the commercial catches. They are then 8 to 10 inches long. These yearlings are known in the trade as "tinkers."

Probably the mackerel is as well known as any other species on the market. Salted mackerel are widely exported, and are to be found in grocery stores in the West Indies and South American countries. Not only are large quantities salted, but the fish is also sold fresh and smoked.



Hashime Murayama

Painting by Hashime Murayama

“SALAD DAYS” FOR THE TUNA COME AFTER CAPTURE

Nearly the entire commercial catch of **Bluefin Tuna** is canned. Biggest member of the mackerel family, this giant fish is also among the largest of all sea denizens; individuals have been taken weighing more than 1500 pounds. It is almost world-wide in distribution. On our Atlantic coast it ranges from New England to Florida, and in the Pacific from Japan to Hawaii. In the Atlantic fish it feeds principally on smaller schooling fish. It is one of the world's earnest sport fishes.

Bluefin Tuna*(Thunnus thynnus)*

Usual Weight, 100 to 250 Pounds

This giant mackerel is the largest member of its family, and is among the largest of all fishes. The largest individual on record, taken off the coast of New Jersey, was about 14 feet long and weighed 1,600 pounds. Another giant is reported to have weighed 1,500 pounds, and several more weighing 1,200 to 1,300 pounds were taken on the coast of Nova Scotia. It is on record also that in one season a single fisherman harpooned 30 tuna having an average weight of about 1,000 pounds. Though enormously large fish occasionally are caught, the usual size is well under 250 pounds.

The bluefin tuna is almost world-wide in occurrence, being found on both sides of the Atlantic and the Pacific. In Europe it ranges from Norway to the Mediterranean Sea, and southward on the African coast to the Cape of Good Hope. On the Atlantic coast of America it ranges from Newfoundland south at least as far as Florida. (Tuna also occur in the West Indies, but the fish of that region may be of a different species.) On the Pacific coast the bluefin tuna is found from Washington to Lower California. It was once (probably erroneously) reported from the Galapagos Islands.

Although the Pacific tuna and the Atlantic tuna of Europe and America are considered as of one species (concerning which, however, some doubt exists), there is a very great difference in size attained in different regions. Fish taken on the Pacific coast seldom exceed 250 pounds. In the Mediterranean Sea a 500-pound fish is a giant, but on the Atlantic coast of North America fish of that weight are not rare.

Comparatively little has been learned about the migrations of this sea rover. An Italian ichthyologist during recent years has endeavored to learn something about their wanderings from the origin of hooks sometimes found imbedded in the flesh of captured fish. By this method he has found out that occasionally bluefin tuna migrate from Italy to the Azores, and from Spain to Norway.

This same investigator recovered from a fish taken off Sardinia a hook of an old discontinued model, formerly manufactured by an American firm in Akron, Ohio. This find tends to show that this particular fish had broken away when hooked in America and afterward had crossed the Atlantic.

Little attention has been given to their local movements on our Atlantic coast. It is known only that the fish appear in schools in the spring and leave again in the fall. Their winter home has not been found.

Though the giant fish mentioned were not conquered with rod and reel, fish weighing 750 to 950 pounds have been landed by sportsmen.

The bluefin tuna generally has been considered one of the world's gamest fish. Sportsmen on the Pacific coast have long sought this "tiger of the California seas." It is only within comparatively recent years, however, that tuna fishing, as a sport, has gained in popularity on the Atlantic coast of America, where the largest fish occur.

Tunas are beasts of prey, and there can be little doubt that large quantities of food are required for their nourishment. They are a schooling fish, like all their relatives, and feed principally on schooling fish. The tuna is one of the chief enemies of its relative, the mackerel, and also of the menhaden and herring. Neither are dogfish (sharks) spared, for whole dogfish, weighing as much as eight pounds, have been found in their stomachs. Tuna, in fact, feed on virtually all smaller schooling fish, and also on squid. It is indeed probable that their local abundance and movements are governed in large part by the schools of fish on which they prey.

The tunas themselves are preyed upon by killer-whales, which are said to seize the tuna by the nape, cut the spinal cord, and thus kill them instantly. The fish sometimes become stranded, presumably either while pursuing prey or perhaps while fleeing from enemies.

The eggs and young of the tuna have not been found in American waters, apparently no young fish under 6 to 10 pounds having been taken. The eggs have been found, however, in the Mediterranean Sea, where the fry, too, have been taken. It is reported that the fry also have been found in the mid-Atlantic.

Although the tuna has been highly regarded as a food fish in the region of the Mediterranean Sea and in California for many years, commercial fishermen on our Atlantic coast considered them a nuisance until recently, for they had no sale value and they were prone to follow mackerel and herring into nets, only to tear their way out again. Many years ago a few were harpooned for the extraction of oil. That industry failed to be profitable and was discontinued. The statistical records of the U. S. Bureau of Fisheries show, however, that by 1935 the fair quantity of 562,600 pounds was taken on the New England coast, and in 1937 the catch had increased to about 1,000,000 pounds. There was still further increase in 1938, when at least one tuna vessel came from the Pacific coast, principally to test the fishery. Nearly the entire catch in New England, as elsewhere, was canned.

Most of the fish during the last few years were taken with purse-seines. A considerable quantity is caught in pound nets, some are taken with gill nets, and a few are harpooned.

Of these large, powerful animals Charles F. Holder has said, "Weight for weight, they have double the fighting power of the tarpon. They are living meteors that strike like a whirlwind and play like a storm."



Hashime Murayama

Painting by Hashime Murayama

CHIEF THREATS TO THE BONY, BUT DELICIOUS, SHAD ARE OVER-FISHING AND POLLUTION OF ITS SPAWNING STREAMS

The **Shad**, largest member of the herring family in American waters, is an anadromous fish, ascending fresh-water streams to spawn. It is particularly liable to extinction because it can be netted only during the spawning season. The larger fish are always females, or roe shad. The species enters all suitable streams from the St. Lawrence River in Florida to the Gulf of St. Lawrence. Yet the extinction of the Gulf of St. Lawrence shad has been feared to cause this popular food fish from extinction.

Shad

(*Alosa sapidissima*)

Usual Length, 18 to 24 inches

The shad is the largest member of the herring family in American waters. Individuals weighing as much as 12 and 14 pounds have been reported. Fish exceeding a weight of 8 to 10 pounds, however, are not numerous. The larger fish are always females, or roe shad. In a representative collection of adult shad, taken in Chesapeake Bay, the 35 bucks included ranged in length from 14 to 23 inches, and in weight from 2 pounds and 4 ounces to 5 pounds, whereas the 21 females in the catch ranged from 18 to 25 inches in length, and from 3 pounds and 11 ounces to 7 pounds and 14 ounces in weight.

The shad is an anadromous fish, ascending fresh water streams only to spawn. Almost immediately after the reproductive products have been cast, the fish return to the sea, where they spend most of their lives. All suitable streams from the St. Johns River in Florida to the tributaries of the Gulf of St. Lawrence are entered. In Florida the fish appear in the rivers in November or December. Northward they enter the streams progressively later. In the Chesapeake Bay region they generally arrive early in March. In the streams of New York and Connecticut they are expected in April and in the St. Johns River, New Brunswick, about the middle of May.

Because the shad was highly esteemed on the Atlantic, its introduction on the Pacific coast was undertaken. The first shipment, consisting of 12,000 fry from the Hudson River, was made in 1871. These fry were planted in the Sacramento River. Other shipments were made in 1873, 1876, and 1880. From these early plantings shad soon became common to numerous from the Columbia River to Monterey.

It was long believed that the shad migrated northward along the coast as the temperature of the water increased. That seems not to be true, however, for it now appears much more likely that the migrations are inshore and off-shore. Nevertheless the "permanent" home of the shad is unknown to man.

Adult shad eat little or not at all while in fresh water. The comparatively few taken at sea had fed principally on small shrimps, amphipods, small fish, and algae. The young shad while in fresh water feed freely on small crustaceans, insects, insect larvae, and fish fry.

Just how numerous the shad were and how extensively they were utilized prior to 1880 will never be known, since no adequate statistics are available prior to the year named. Over a considerable period of years after statistical canvasses were made, or 1880 to 1900, the catch in the different groups of States along the Atlantic remained more or less sta-

tionary. However, during the last 40 years or so the yield has declined steadily. This decline is very evident from statistics. In 1897 the commercial catch for the Atlantic coast was about 48,500,000 pounds, whereas in 1935 it had dropped to about 8,200,000 pounds.

On the Pacific coast, following the introductions, the largest catches there were made from 1911 to 1917, when the yield fluctuated between 4,175,000 and 7,478,000 pounds. Since 1917 the general trend there has been downward, the catch in 1935 being 2,414,000 pounds.

Because shad can be taken only during the spawning season, there is danger of overfishing, and this without doubt has contributed to the decline in the abundance of shad. A further factor is the obstruction of streams, hindering or making passage impossible. However, the chief cause of the decline of the fishery very probably is the extensive pollution of our streams. The Chesapeake Bay region remains as the chief shad producing center, perhaps because the waters there are less polluted than in many other areas.

The shad was one of the first fish in America to receive the attention of fishculturists. As early as 1867 a successful hatching apparatus had been invented, and in 1872 the U. S. Fish Commission began artificial cultivation, which has been continued to the present. Many millions of shad fry have been hatched and liberated. Artificial cultivation has not succeeded, however, in reestablishing the shad in its former abundance, as was hoped. Indeed, it has not been sufficient to prevent a general and serious decline.

Since the shad rarely feed while in reach of man, that is, while in or near the mouths of streams, or bays or sounds, they cannot be tempted with bait. Therefore they must be netted. The fish are taken chiefly with three kinds of gear. The most important of the three is the gill net; next in importance is the pound net; and then the haul seine. All of these different types of gear are effective. Any one who has visited different parts of Chesapeake Bay during the shad fishing season must have been impressed with the many pound nets, fyke nets, gill nets, and other gear in use. The general scene makes one wonder how any fish reach the spawning grounds.

Spawning occurs shortly after the shad enter fresh water. It has been estimated that the average number of eggs produced by a female is about 25,000 to 30,000, though exceptional individuals may have 100,000 or even 156,000.

The newly hatched fish are scarcely 10 millimeters long, but they grow rapidly, reaching a length in the Potomac River of 3 inches in October, at the age of about 6 months. At that time the young begin to migrate to the sea, where they remain until mature, at the age of probably about three or four years. At maturity many presumably return to the rivers in which they were born.



Photograph by Willard R. Culver

WITH A LONG-HANDLED DIP NET, A FISHERMAN SCOOPS UP THE IMPOUNDED CATCH

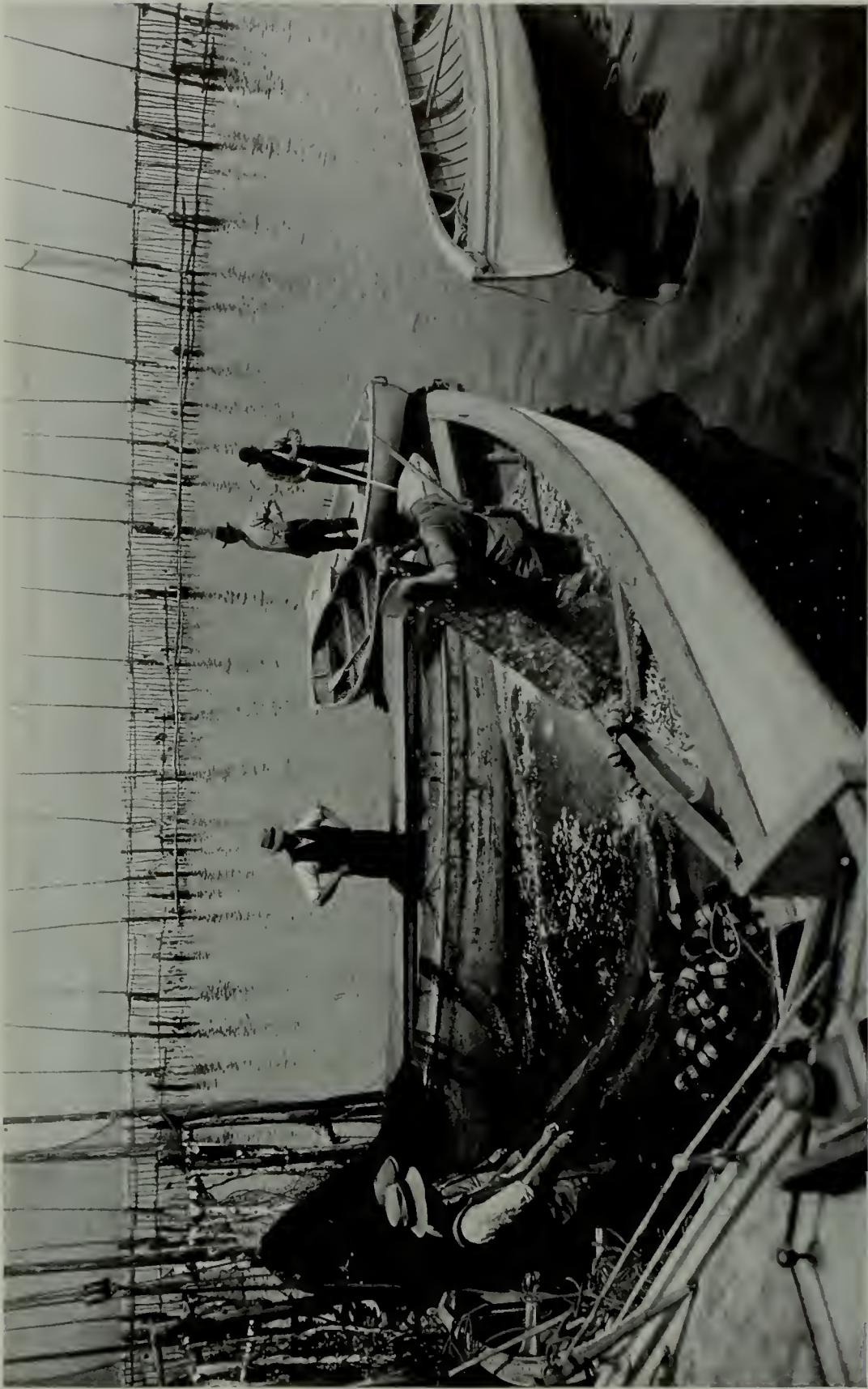
A small vessel, fishing off Newport, Rhode Island, takes aboard the haul of a trap net. Men in the rowboat have crowded the fish into one corner of the net by pulling it up in front of them. Newport is a center for the important fisheries around Block Island.



Photograph by John N. Meissner

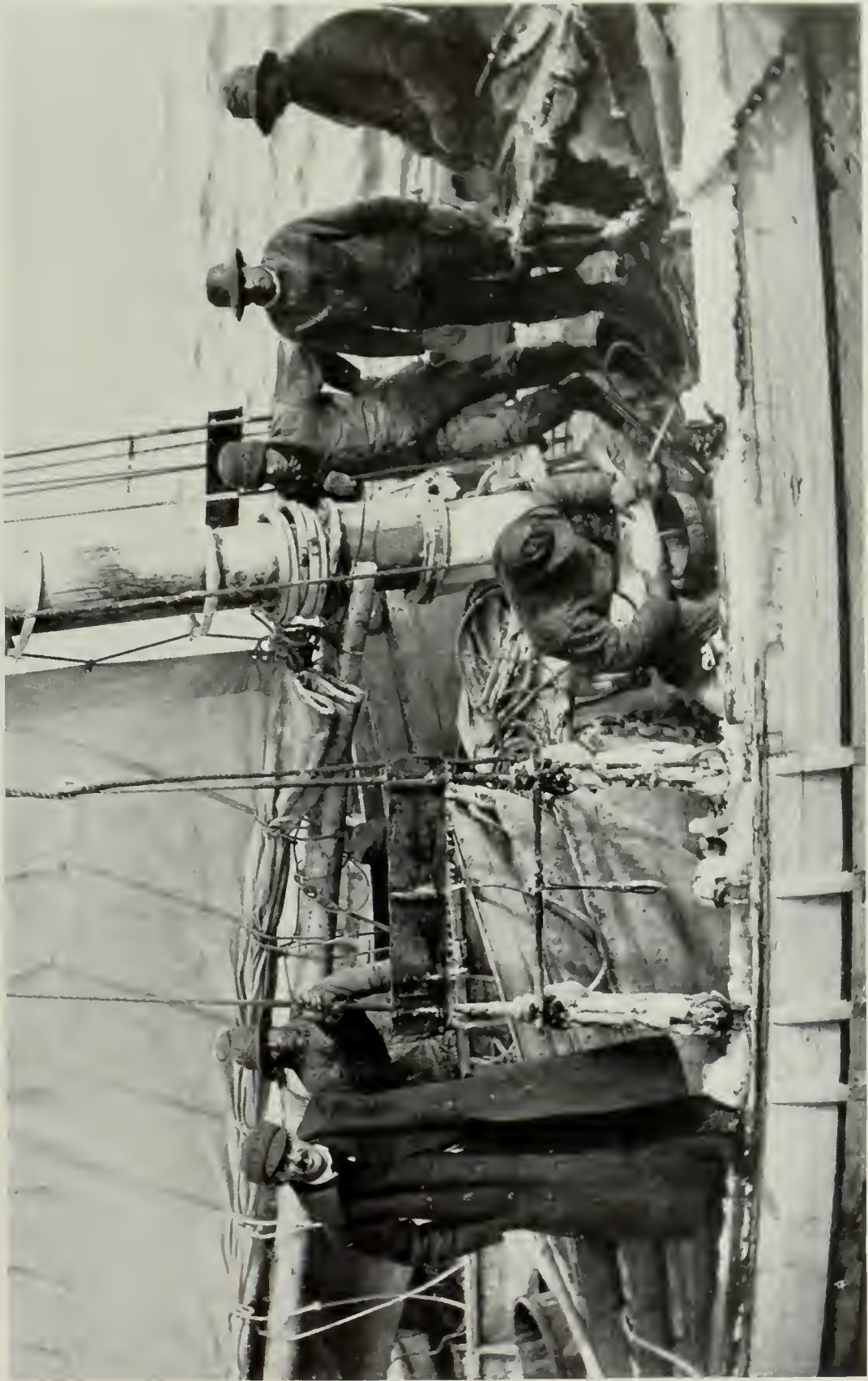
TEN THOUSAND ALEWIVES ARE ENMESHED IN JUST 14 MINUTES

At the commercial alewife run at Star-Mills, Middleboro, Massachusetts, a 75-foot net gathers in the abundant catch. The fish begin to run there about March 28 and keep crowding upstream until the middle of May.



UP TO THE KNEES IN SARDINES, A FISHERMAN EMPTIES THE SILVERY HARVEST INTO HIS BOAT

A weir trap in New Brunswick has captured a good haul. Though fish are not commonly regarded as meat, there is no characteristic difference between fish flesh and that of mammals. Protein and water form the bulk of fish flesh, and, pound for pound, there is almost as much protein in fish meat as in beefsteak. Oily fish, such as shad, herring, and eel, are especially nutritious. Fish roe usually contains more protein than beef and some fat in addition.



Photograph from U. S. Bureau of Fisheries

HATCHERY EXPERTS REMOVE FROM LIVE FISHES EGGS AND FERTILIZING MILT TO BE USED IN ARTIFICIAL PROPAGATION

In biological stations all along our eastern coast, scientists and technicians are furthering practical methods for restoring depleted species. Restricted seasons and regulations limiting the legal catch-size help to protect many kinds from overfishing.



NOVA SCOTIA "BLUENOSES" UNLOAD HERRING FROM THEIR SMALL BOATS INTO A FLOATING STORAGE BIN

The herring family is large and prosperous. It includes such diverse members as the shad, the pilchard, the anchovy, the sprat, and the whitebait. All branches of the family have small mouths and have either no teeth at all or very small ones. They are therefore, for the most part, obliged to find sustenance in the myriad minute animals diffused through the waters of the ocean or lurking among the vegetation at the bottom.



TIGHT-PACKED CODFISH LEAVE LITTLE ROOM FOR THEIR CAPTORS

Although the craft is already full to the gunwales, Banks fishermen spill another load aboard. Cod-liver oil as now defined includes oil from any member of the codfish family. Few purchasers realize that the pollock is one of the principal sources of this medicinal extract.

Alewife

(*Pomolobus pseudoharengus*)

Usual Length, about 11 Inches

The alewife is a species of herring, like the shad, though much smaller. The greatest length attained is about 15 inches, and the usual length only about 11 inches. The female apparently grows a little larger than the male.

This fish also is anadromous, and runs up streams to spawn, from North Carolina to Nova Scotia. It has become landlocked in some lakes in New York, and in Lake Ontario, where it multiplies rapidly, but has become so dwarfed that it has little or no value. Periodically many die, and their disposal, at times, is a serious health problem.

Alewives generally arrive in the streams ahead of the shad, and about three or four weeks earlier than their close relative, the glut herring (*Pomolobus aestivalis*). In the Chesapeake Bay region they are expected some time in March, and in Maine not until late in April or May.

Any discussion of the abundance of the alewife must include the glut herring also, because the two are seldom, if ever, listed separately in statistical tables. Shad undoubtedly were numerous during colonial days, but not so numerous as these anadromous herrings. In the words of an early writer "experience hath taught them at New Plymouth that in April there is a fish much like a herring that comes up into the small brooks to spawn, and when the water is not knee deep they will presse up through your hands, yea thow you beat at them with cudgels, and in such abundance as is incredible."

However, this fish, like the shad and other species, also has declined in abundance. The chief causes of the decline evidently are the same as for the shad, namely, overfishing, obstructing streams used as spawning grounds, and especially polluting of the rivers. The great decrease during the last quarter of a century or so is evident from the fact that the catch for the United States, according to the statistics that were available in 1908, was 52,061,000 pounds, whereas the latest statistics in 1937 showed a total yield of only 29,178,000 pounds. In the Chesapeake Bay region, where the yield has declined correspondingly less than elsewhere, the catch fell from 30,408,000 pounds in 1890 to 12,057,000 pounds in 1936. It should be stated, however, that the yield has fluctuated greatly in the past, and that a temporary or a partial recovery at least may be hoped for.

Alewives are taken principally with haul seines, pound nets, and drifting gill nets. Much of the catch is salted, and a considerable portion of the roe is canned.

The alewife is prolific, for it has been determined that the average yield of eggs by a

female is near 100,000. The eggs are about 0.5 millimeter in diameter, and hatch in six days at a temperature of 60° F. The young are about five millimeters long at hatching. They grow fast, and are about 70 millimeters (2¾ inches) long in November, at the age of about six or seven months, when they begin their journey to their home in the sea.

Herring

(*Clupea harengus*)

Usual Length, 10 to 15 Inches

The herring is a North Atlantic fish, occurring on the American coast from Cape Hatteras northward to Labrador and Greenland, and on the European coast from the Straits of Gibraltar to Norway. In America it is most numerous north of Cape Cod, though taken commercially as far south as Virginia. It is probably the most important food fish in the world. The heavy drain on the fishery, extending over many years, especially in Europe, does not seem to have diminished the supply greatly, if at all. According to the latest statistics available in 1937, the yield in the United States alone was 55,125,000 pounds.

The herring is strictly a sea fish, for unlike the other herrings, the shad and alewife, illustrated in this book, it does not enter fresh water. It schools along the shore during the warmer part of the year, though some schools, presumably consisting of immature fish, remain off shore. When cold weather comes, the fish supposedly withdraws to deep water. During the time near the shore the spawning activities take place. The reproductive season is a long one. In some localities, at least, spawning takes place in spring, summer, and fall, spring and fall being the chief seasons.

The eggs are 1.0 to 1.4 millimeters in diameter, adhesive, and heavier than sea water, sinking to the bottom where they stick to the sand, gravel, or any other object with which they come in contact. The period of incubation is about 11 days at a temperature of 50°. The newly hatched fish are extremely slender, and about one fourth of an inch long. Growth is rapid, fish at one year of age sometimes reaching a length of three and a half to five inches. At this size they are utilized as sardines. The large ones are used fresh, salted, and smoked. Herring also are used as bait in line fishing for cod, haddock, and other fishes.

Aside from the herring's usefulness as food for man, it is of much indirect economic importance as food for other fishes, including such important species as the cod, haddock, halibut and bluefish, all of which feed on them extensively.

The food of the herring itself consists of such small organisms as diatoms, copepods, larval crustaceans and mollusks, and many other forms. Thus, they convert into flesh organisms not utilized by many other adult fish that otherwise would be wasted.



Hashime Murayama

Painting by Hashime Murayama

"KIPPERS FOR BREAKFAST!" SPELLS WAR ON ALEWIFE AND HERRING

The **Alewife** (top fish), variously known as the branch herring, big-eyed herring, and wall-eyed herring, is an anadromous species found from North Carolina to Nova Scotia. Probably the most important food fish in the world, the **Herring** (pair below) is distributed throughout the North Atlantic. Aside from the herring's usefulness to man, it has great indirect importance as one of the favorite foods of many other valuable fishes.

Tautog

(*Tautoga onitis*)

Usual Length, 12 to 18 Inches

The tautog is a member of the very numerous labrid or lipped family (Labridae), consisting of about 450 species mostly living in tropical and subtropical regions. Of the western Atlantic species only the tautog and the cunner regularly range north of North Carolina. These two species are almost separated from the rest of the family in their northern homes. In fact, the cunner, which is found from Labrador to the mouth of Chesapeake Bay, occupies no common ground with any of its southern relatives, and the range of the tautog, which extends from the Bay of Fundy to South Carolina, overlaps only slightly with a few southern species which are summer visitors on the coast of the Carolinas.

The tautog has several names. In New England it is regularly called tautog. In New York and New Jersey it is known as the blackfish. In Chesapeake Bay it occasionally is called blackfish, other names being chub, salt-water chub, and black porgy. Farther south it is known as the oyster fish.

Many of the southern species of the family are brilliantly colored, rivaling the parrotfishes in their display of green, red, and blue. The tautog, however, is very somber in color, being either greenish or brownish, with irregular blackish bars or blotches, or plain blackish. The fish are able to change their color to a considerable degree to correspond with the ground on which they live.

The tautog has a heavy body, and a very stocky tail. However, some individuals are notably stockier than others. For example, a fish 13 inches long, taken in Chesapeake Bay, weighed one pound and seven ounces, whereas another specimen from the same general vicinity, 14 inches long, weighed only 13½ ounces. The largest individual of which there is a definite record was 36½ inches long and weighed 22½ pounds. That fish truly was a giant among his fellows; for fish weighing as much as 12 to 14 pounds are rare, and the average weight of market fish is not more than 2 or 3 pounds.

The tautog has smaller scales than most other species of its family. Its body is always covered with mucous, making it quite eel-like in slipperiness. It has a long fin on the back which is made up partly of spines and partly of soft rays. In these respects it agrees with its nearest southern relative, the Spanish hogfish of Florida and the West Indies. However, several of the anterior spines in this fin are greatly enlarged and produced in the southern hogfish; whereas all the spines of the tautog are of nearly uniform length. The tautog, like virtually all its relatives, has very strong teeth in the jaws, the anterior ones being incisor-like. In addition it has strong conical teeth

far back in its mouth, or almost in its throat, which are known to science as pharyngeal teeth. That this fish has need for this double set of strong teeth will become evident when we learn what kinds of food it eats.

This fish is strictly coastwise, seldom being taken more than a mile or two from the shore. On the other hand, it avoids fresh or even brackish water. Its favorite habitat is among rocks, ledges, old wrecks, piers, and breakwaters.

In the South the fish sometimes occur on oyster reefs, feeding on oysters, and barnacles, growing on oysters, habits that have suggested the name oystersh. In its habitat and to a large extent in its feeding habits the tautog is identical with, or at least strikingly similar to, the sheepshead (*Archosargus probatocephalus*) to which it is only distantly related structurally.

The tautog feeds on invertebrates, chiefly on shellfish, and especially on mussels, clams, oysters, scallops, and barnacles. It also eats hermit crabs, fiddler crabs, shrimps, amphipods, isopods, and sand dollars. It is evident that strong teeth are required to pick barnacles off rocks and piling, and to remove oysters from their moorings. For this it uses its strong front jaw teeth. Even stronger teeth are necessary to crush the harder shellfish upon which it feeds, and for that purpose it uses its pharyngeal teeth.

The tautog is a good game fish and provides rather extensive sport. Since its mouth is not large, small hooks must be used. When once hooked, it puts up a good fight. Large quantities are taken commercially with hooks and lines. Commercially it is taken, also, with otter trawls, and to a limited extent with pound nets and floating traps.

The tautog is among the fish of lesser importance commercially. The latest statistics available, which are for 1935, show an annual catch of 304,000 pounds. This catch was made mostly between Cape Cod and Delaware Bay. South of Virginia the tautog is not taken in sufficiently large quantities to be listed separately in the markets, the small catches being shipped with other species as "mixed fish."

Spawning takes place in late spring and early summer. The eggs are buoyant, and are close to one millimeter in diameter. Incubation requires only about 42 to 45 hours at a temperature of 68° to 78° F. The newly hatched fish is only about 2.2 millimeters long.

For a few days the larvae float helplessly on their backs. During this time they feed on the yolk they have retained from the egg. When they right themselves, the mouths have opened and they are ready to feed. This is the most critical stage in the life of a fish, because proper food often is not available. The young of this species acquire the characters of their parents very early, for they look so much like the adults when only a half inch long that they are easily identified with them.



Hashime Murayama

Painting by Hashime Murayama

SHELLS AND ALL, THE TAUOTOG SWALLOWS ITS CHOSEN FOOD

A member of the numerous group known as lipped fishes, the stockily-built **Tautog** ranges close alongshore from the Bay of Fundy to South Carolina. It has several names, tautog and blackfish being the commonest. To crush its diet of mussels, clams, oysters, scallops, barnacles, crabs, and shrimps, this species is equipped with incisorlike front teeth and very strong conical teeth far back in its mouth. Indigestible parts are regurgitated.

Butterfish

(*Poronotus triacanthus*)

Usual Length, 7 to 9 Inches

The butterfish and the harvestfish (*Peprilus alepidotus*) are the only two members of the butterfish family occurring on the Atlantic coast of the United States. Both are excellent foodfishes. The butterfish has the wider range, being found from Nova Scotia to Florida; whereas the harvestfish (assuming that the harvestfish of tropical America is a different species, concerning which there is some doubt) ranges only from Cape Cod to Florida. The butterfish is taken occasionally all the way from Nova Scotia to North Carolina, while the harvestfish is listed only from Maryland to North Carolina in the statistical records of the U. S. Bureau of Fisheries for 1936.

Poronotus triacanthus has several names, being known as dollarfish in Maine, as butterfish in Massachusetts and Norfolk (the name used for *Peprilus alepidotus* at Beaufort, N. C.), and pumpkinseed in Connecticut. Other local names are harvestfish (a name more widely used for *Peprilus alepidotus*), shiner, and skipjack.

It is interesting, as an illustration of the severe mutilations that some fish can overcome, to mention that Hildebrand and Schroeder, in their "Fishes of Chesapeake Bay" stated that they had an adult butterfish that at some time had suffered an injury in which it had lost its snout from the eyes forward. The wound had healed completely, and notwithstanding that the fish had not even rudiments of jaws, and only an oval-shaped opening for a mouth, this specimen was in good condition when caught, appearing fatter than many normal individuals.

The butterfish lives along the shores in the bays, sounds and inlets during the summer, but when winter comes it disappears. In Chesapeake Bay it is caught from May to November. During recent years it has been taken in rather deep water in the winter trawl fishery that has been developed off the Virginia Capes since 1930. These off-shore winter catches indicate that this fish has its winter home in the deeper water at no great distance from the shore, where it goes to escape the low winter temperature of the shallow shore waters.

This species feeds on small fish, squids, amphipods, shrimps, annelids, and ctenophores. Often the stomach contains only a mass of flocculent material, which apparently consists in part of crushed plant tissue.

The total catch in the United States for 1935 in the New England States, and for 1936 in the more southern States, was 358,000 pounds.

The butterfish spawns during the summer, or from June to August. The eggs are buoyant, transparent, spherical, and 0.7 to 0.8 millimeter in diameter. They hatch in about 48 hours in a temperature of 65° F. The newly hatched

larvae are about two millimeters long. At one year of age, according to the limited evidence that has been accumulated, the fish are three to five inches long, and at the age of two years they are six to seven. Though a maximum length of 12 inches is attained, and fish 10 to 11 inches long are not rare, fish scarcely six inches long sometimes are sexually mature.

Scup

(*Stenotomus chrysops*)

Usual Length, 8 to 10 Inches

The scup belongs to the porgy family, which includes also the sheepshead, the pinfish, and the southern porgies. It ranges between Maine and South Carolina, and is common from Cape Cod to the Virginia Capes. It occurs along the shores only during the summer. In Chesapeake Bay the scup is taken from April to October. Northward it appears in the shore waters somewhat later and departs somewhat earlier. Upon the approach of cold weather, a migration to the deeper waters off the Virginia Capes takes place, which is a fact demonstrated by tagging experiments carried on by investigators of the U. S. Bureau of Fisheries.

This species, like many others, has several local names. It is the scup in New England; the porgy in New York; the maiden, fair maid, and ironside in Chesapeake Bay; and the porgy again in South Carolina.

The scup lives principally on the bottom, preferring smooth hard sand. It feeds largely on small crustaceans, mollusks, worms, and small fish. Scup bite greedily on clams, squids, bits of crabs, and bloodworms, and furnish sport for a large number of anglers, particularly along the coast of New Jersey and New York. Commercially it is caught chiefly with pound nets, otter trawls, and purse seines.

Though the scup has been an important food fish along the Atlantic coast since colonial days, the annual catch during recent years has increased greatly. In 1926 the total catch was 5,319,000 pounds. The amount increased to 15,362,000 pounds in 1936. A winter trawl fishery developed off the Virginia Capes since the discovery of the winter home of the scup. In about 1930, has contributed generously to the catch. However, the annual catch in the shore fisheries has increased also with little increase in fishing. Presumably several successive good spawning seasons with a high rate of survival have increased the population.

Spawning continues from May to August. The eggs are buoyant, transparent, and spherical, measuring about one millimeter in diameter. They hatch in about 40 hours at 72 degrees. The fish is about two millimeters long at hatching, and attains a length of perhaps three to four and a half inches by the end of its first summer. Sexual maturity seems to be attained at a length of four to five inches, when the fish are only in their second year.



Hashime Murayama

Painting by Hashime Murayama

BY NUMEROUS OTHER NAMES, BUTTERFISH AND SCUP TASTE JUST AS GOOD

Known as dollarfish in Maine, **Butterfish** in Massachusetts and Virginia, and pumpkinseed in Connecticut, *Poronotus triacanthus* (pair at top) spends the summers along the shores of bays, sounds, and inlets and apparently winters in deeper water. It is found from Nova Scotia to Florida. The **Scup** of New England (bottom fish) is the porgy in New York, the maiden, fair maid, and ironside in Chesapeake Bay, and the porgy again in South Carolina.

Atlantic Salmon

(*Salmo salar*)

Usual Length, 20 to 30 Inches

When the white man first came, he found *Salmo salar* common in every river in New England not barred by impassable falls. However, as industrial developments have progressed, one stream after another has been so obstructed by dams that the fish no longer can enter, and except in Maine the salmon is almost a historic fish in United States waters.

Its natural range reached to both sides of the North Atlantic, extending on the American coast from Greenland to Cape Cod, and probably to the Hudson River. In Canada, where industrial developments have progressed less rapidly, and where wise measures of conservation, such as providing fishways at dams, and limiting netting at the mouths of streams, have been practiced, the salmon population has been maintained at one level and in some instances has even increased.

The total catch for Maine in 1934-35 was only 39,400 pounds, whereas the catch reported for that State in 1889 was 152,740 pounds. The recent catch for the State of Maine showed an increase, however, for in 1916-17 only 20,000 pounds were reported. This increase and the increase in some of the Canadian waters offer some hope that the measures of conservation now used will save the species and the fishery in those waters that are still regularly visited by the spawning fish.

The Atlantic salmon, like the shad and the alewives, is anadromous, running far up the rivers to spawn. However, it spends more time in fresh water than the other species mentioned, or at least the young fish remain longer. In Maine most of the young run down to the sea during the third summer of life, but some go by the end of their second summer, and others remain in fresh water until they are three, four, five or even six years old. Their habits in this respect do not only vary within a restricted area, but differ according to locality.

Most of the fish are five to six inches long when they enter salt water, which recalls Izaak Walton's remark that "he is ever bred in fresh rivers and never grows big but in the sea. * * * He has, like some other persons of honor and riches which have both their winter and summer houses, the fresh for summer and the salt water for winter to spend his life in."

The young salmon while they live in fresh water are known as "parr." As they enter tidewater they put off their youthful barred and spotted pattern, and take on the silvery coat worn by salmon during their sojourn in the sea. At this stage in life they are known as "smolts." They remain about the shores, near the mouths of rivers, and in the estuaries for some time, and then disappear. There is no good reason to believe that they go far off

shore, though little is known of their movements in the sea.

After the salmon enter salt water, they usually remain there until the urge to spawn drives them back to their earlier homes. However, this is not a hard and fast rule, since some immature fish, known as "grilse", sometimes accompany the adults on their spawning migration. Growth in salt water is very rapid, young fish often growing from a length of five or six inches to 16 inches within a year. Like most other northern fish the salmon does most of its growing during the summer. However, the rate of growth and size attained by different individuals seems to be unequal.

It has been determined that those salmon that begin to spawn early in life never grow large. That is, those fish that return to the rivers to spawn after passing only two years in the sea will always remain small, whereas those that begin spawning after spending three, four or even five years in salt water reach a large size. It is believed that the exceptionally large fish are "maidens" entering fresh water to spawn for the first time. Investigators have found that the span of life of the salmon is about eight or nine years.

Adult Atlantic salmon, like the Pacific salmon, lose their bright colors and their trim shape, and the males develop hooked jaws, upon entering fresh water. Unlike the Pacific salmon they do not die after spawning, but may return to spawn three or four times.

The salmon is highly carnivorous, feeding altogether on live animals. It includes in its diet many different sorts of fish, but its favorites are said to be lance, herring, and capelin. The salmon feeds extensively on crustaceans, the sand flees (*Gammarus*), and shrimp being among the important ones. While in fresh water, adult salmon feed little, and near spawning time not at all.

Some salmon attain a great size; the largest one ever reported weighed 103 pounds. This fish was taken in Scotland. No fish nearly as large is recorded from America, where 50-pound fish are unusual, and 10 pounders near the average weight at maturity.

Spawning occurs in the American rivers still visited by salmon in October and November. The eggs, which are about six to seven millimeters in diameter, are laid on gravelly bottom in a smooth shallow trough made by the female, wherein they are covered with gravel. There they lie in the cold water during the winter, developing so slowly that hatching does not occur until the following April or May.

The newly hatched salmon is 15 to 20 millimeters long, and is almost helpless from being burdened with a large yolk sac, upon which it subsists for some time. When the yolk is absorbed, the young fish begin to swim and to feed. After remaining in fresh water two winters and two summers, they migrate to their more permanent home in the sea.



Hashime Murayama

Painting by Hashime Murayama

SWIMMING THE ATLANTIC IS A SALMON THAT DOES NOT DIE AFTER SPAWNING

Unlike its Pacific namesakes, the **Atlantic Salmon** may return three or four times to reproduce in fresh-water streams. It passes at least half its life in the ocean. On the American side of the Atlantic this first-class food and game fish originally ranged from Greenland to the Hudson River. Now it is extremely rare for a specimen to be caught south of Maine. In rivers of eastern Canada there is no finer angling sport than fly-fishing for these splendid fish.



IN CAPE BRETON WATERS, SWORDFISH ARE CAUGHT FOR MARKET—AND FOR SPORT

Commercial swordfishing is an old story on the east and north coasts of Cape Breton Island, Nova Scotia. But recently, salt-water anglers have captured splendid fish in those regions. Swordfish, which like deep water, have been taken on trawl lines at a depth of 80 fathoms. However, they loaf along the surface frequently enough to be engaged in numerous rod-and-line battles.



Photograph by Luis Marden

MONSTER AND MIDGET—AND BOTH LOBSTERS!

The State of Connecticut lobster hatchery at Noank exhibits a sixteen-pound, fifty-year-old patriarch.



Photograph by Paul Pryor

WITH A DEFT TWIST, A BIOLOGIST TAGS A HARDHEAD

At the Chesapeake Bay Biological Station at Solomons Island, Maryland, the fish is marked with a small celluloid tag which is secured by a small wire thrust through the back. Data of place, size, species, and age are recorded. If the tag is returned, the movements of the fish can be deduced.



Hashime Murayama

Painting by Hashime Murayama

FOR THRILLING AND ENGAGING SPORT, TRY ANGLING FROM A SMALL BOAT FOR SWORDFISH

Sometimes reaching a weight of 800 pounds, the **Swordfish** rivals the shark in size and strength. Its distribution is almost world-wide; it is the *zwaard-fis* of The Netherlands, the *sofia* of Italy, the *espada* of Spain, and the *épée de mer* of France. On the American side of the Atlantic it ranges from Cape Breton to Cuba. There have been many reports of small vessels limping into port leaking badly as a result of attacks by wounded swordfish. (See illustrations, page 100.)

Swordfish

(*Xiphias gladius*)

Usual Weight, 250 to 400 Pounds

The swordfish was named *Xiphias* some twenty-three centuries ago by Aristotle. It is allied to the mackerels, but its nearest relatives are the spearfishes and the sailfishes. Its range is almost world-wide, for it occurs in the open sea of the Indian and the Atlantic and Pacific oceans on both coasts. On the American side of the Atlantic it ranges from Cape Breton to Cuba.

It rivals the shark both in size and strength, sometimes reaching a weight in excess of 800 pounds, although most of those caught weigh less than half as much.

Usually appearing on the shoals and banks in June, and staying until the colder fall months set in, it is believed to come out of the deeper waters in search of food, since its spawning grounds are not in shallow regions. Apparently it follows the menhaden and the mackerel. Old fishermen have a saying that where you find mackerel you may expect swordfish.

Every now and then it leaps entirely out of the water. Old fishermen attribute this to tormenting parasites; but modern authorities disagree with this theory. Be that as it may, one authority tells us that it strikes with the force of fifteen double-hammers and with the velocity of a swivel shot.

Its stupidity in attacking ships and other objects sailing the seas is so great that Oppian tells us that "Nature her bounty to his mouth confined, gave him a sword, but left unarmed his mind".

The feeding habits of the swordfish are striking. It is said that it swims under a school of small fishes, and then, suddenly rising to the top, thrashes about with its sword, killing a number of its prey in the act. These it promptly devours and then repeats the performance.

It is said the swordfish never comes to the surface except in moderate, smooth weather. Once it is sighted, the lookout at the masthead "sings out," and the skipper takes his place in the "pulpit," on the end of the bowsprit, holding the harpoon pole in both hands by the small end. Directing the helmsman, he guides the vessel toward the quarry, and when the fish is eight or ten feet off the prow, rams the harpoon into its back. The fish is allowed plenty of line, and then two men go out in a yawl and maneuver the victim alongside, where it is killed with a whale lance.

There are some of the thrills of whaling in swordfishing, since there is no slow baiting or careful waiting and no bother with nondescript baitstealers. The swordfish is a worthy antagonist, and many a vessel has limped into port, leaking badly as a result of attacks by wounded swordfish. Occasionally a small boat is attacked and the sword rammed through its side.

Appreciation of the meat of the swordfish by Americans is recent. Down to the middle of the last century it was not salable in Boston, and brought a very low price in New York. Early in the present century the meat had gained greatly in favor, and by 1919 the demand exceeded the supply. Fishermen have often received as much as 25 cents a pound for their catch. At that price a large swordfish is a prize to the fisherman who is lucky enough to catch one.

The commercial catch in the New England States in 1935 was 2,986,000 pounds, in the Middle Atlantic States 43,000 pounds, and on the Pacific coast 669,000 pounds. The entire catch is utilized in the fresh state, the consumer paying from 30 to 50 cents a pound for swordfish steak.

Swordfish do not travel in schools, but generally singly or at most in pairs. If the crew of one vessel lands one or two a day they are lucky. Though the swordfish has been found in cold regions, it is essentially a warm water fish, being most plentiful in water warmer than 50° F.

Fullgrown swordfish are so active, powerful, and well armed that they can have few enemies. Sperm and killer whales and large sharks alone menace them. It is of record that a good-sized swordfish has been found in the stomach of a tiger shark; also a swordfisherman has related that he saw two large sharks bite off the tail of a large swordfish which he afterward harpooned.

The spawning habits remain largely unknown. The young, down to 10 millimeters in length, were reported more or less from the mid-Atlantic basin by a Danish investigator, and small fish of one and one-half pounds and up are said to be common in the Mediterranean Sea. The smallest swordfish reported from the American coast weighed $7\frac{3}{8}$ pounds, and individuals under 50 pounds are rare. No ripe fish and very few bearing eggs have been found in the western Atlantic. A United States Bureau of Fisheries investigator found a female weighing 150 pounds, taken on the coast of Massachusetts on July 24, 1924, full of partly matured eggs, the total number being estimated at 16,130,400. Another fish from the same general vicinity taken September 10, 1909, contained rather more nearly mature eggs, measuring 1.2 millimeters in diameter. These observations suggest that spawning may take place in late summer or early autumn, but European investigators have believed it takes place in the spring or early summer.

Young swordfish are very different from their parents. Both jaws are greatly prolonged, but as growth proceeds the lower jaw becomes shorter, leaving the upper one as the "sword." Furthermore, the young have a long fin extending over almost the full length of the back, which later becomes separated, making two short fins with a wide space between them.



Hashime Murayama

Painting by Hashime Murayama

AS A TABLE DELICACY, FEW SPECIES SURPASS THE LITTLE SMELT

With a range from the Virginia Capes to the Gulf of St. Lawrence, *Osmerus mordax* is the leading American **Smelt**. Entering streams and brackish bays to spawn during the winter months, it is taken in vast numbers in nets and with hook and line. The species has become very abundant in the Great Lakes, to which it was introduced. Large quantities of smelts are taken during the winter, and most of those caught are frozen and sent to the larger cities

Smelt

(*Osmerus mordax*)

Usual Length, 7 to 9 Inches

The smelts are structurally akin to the salmon, being largely like them except in size. The other chief difference is in the form of the stomach, which, in the smelts is a simple sack, with few or no coeca, that is appendages ending in a cul-de-sac, whereas the salmon have a large number of coeca.

All of the species are small and most of them stick strictly to the sea, although a few go up rivers to spawn, after the fashion of the salmon. All of the abundant species are edible, the flesh being extremely delicate and often full of a fragrant, digestion-aiding oil.

The leading American smelt is *Osmerus mordax*, a shapely little creature that is rarely longer than 10 inches. It ranges along the coast from the Virginia Capes to the St. Lawrence Gulf, and enters the streams and brackish bays to spawn during the winter months, when it is taken in great numbers, with hook and line, and in nets.

In going up streams some of the smelts have lost their way and become landlocked in numerous lakes, such as Champlain and Memphremagog.

This fish has been introduced in several lakes in the Middle West during recent years. In some of the lakes it has become very numerous, showing that the species is able to perpetuate itself without making an annual migration to salt water, as it does along the Atlantic coast. It has become so numerous in some places that it is causing some concern.

A U. S. Bureau of Fisheries investigator wrote in 1936, "The phenomenal spread of the introduced smelt, *Osmerus mordax* (Mitchell), throughout the Great Lakes region during the last decade will be referred to repeatedly in the years to come as another classic example illustrating the many complications that follow the successful establishment of an exotic species of fish. Whether the smelt will ultimately prove to be a curse or a blessing to the Great Lakes States I cannot say. It has been a source of considerable profit for many communities located near smelt waters but it likewise has been a source of great hardship for those commercial fishermen whose nets have been fouled by the entangled fish or whose fishing grounds have been invaded by hordes of these fish."

Another investigator dealing with this introduced fish in Green Bay, Lake Michigan, wrote in 1936, "From July to December the smelt are a serious menace to the commercial fishermen operating gill nets, since they become bridled or caught by their mouths to such an extent that the net will catch only a few, if any, of the more desirable species. * * * This condition has forced the fishermen to cease gill net fishing for part of the season."

The food of the smelt in the Great Lakes, as in the Atlantic, consists largely of invertebrates, though some fish are included. On the other hand, many smelts are eaten by commercially important fishes. This contribution probably more than counterbalances the damage done by smelts.

The fishermen take vast quantities of smelts during the winter, and most of those caught are frozen and sent to the larger cities. Those that are not frozen are termed green smelts and are rated very high on the scale of finely flavored fish. Shrimps and other small crustaceans form the favorite food of this species.

The catch of smelts in New England, where alone on the Atlantic coast they are taken commercially, was 729,000 pounds in 1935, whereas in the same year 1,202,000 pounds were marketed in the Great Lakes region.

It has been stated that the impressive quantity taken in the Great Lakes might have been much greater had more than a small percentage of the commercial fishermen been equipped to catch smelts. The smelt is well regarded as a sportfish in New England, where it attracts many anglers.

The smelts in the lakes run into the lower parts of streams very early in the spring to spawn, just as their ancestors along the Atlantic coast have always done. Females yield from 25,000 to 70,000 eggs, the number varying according to the size of the fish.

Growth seems to be fairly rapid, since a length of about six to eight inches is attained in two years. At the age of two years at least some of the fish are sexually mature and spawn for the first time. It is no wonder that a fish so highly fertile, and maturing in such a short time has no difficulty maintaining itself.

Another smelt that belongs in the fine-food category is the capelin, found from Cape Cod to the Arctic on the Atlantic coast and in Alaskan waters on the Pacific. Its eggs are deposited in vast quantities in the sands along the shore. These, washed upon the beaches, present the appearance of masses of little fishes, eggs, and sand. Hatching takes place in about thirty days, and the youngsters ride the first waves out into the sea.

Still another smelt that meets with favor wherever it abounds is known as the eulachon, or candlefish (*Thaleichthys pacificus*), which lives in great numbers on the Pacific coast from Oregon northward. It is said to be unsurpassed in delicacy of flavor, which is described as exceeding that of any trout.

It is remarkable for its extreme oiliness, which is so great that, when a fish is dried and a wick put into its body, it serves as a candle. It is, of course, from this possible use that the species derives its common name of candlefish. The oil is sometimes extracted and used as a substitute for cod-liver oil. At ordinary temperatures it is lardlike in consistency.

Hashime Murayama



Painting by Hashime Murayama

THE TILEFISH CLAN

A SUDDEN DROP IN OCEAN TEMPERATURE NEARLY WIPED OUT

In 1879 a New England trawler, fishing for cod, took 5,000 pounds of **Tilefish**—the first catch of which there is any record. Three years later, literally millions of the fish were found dead, floating on the North Atlantic. Apparently, a temporary influx of northern water, too cold for the tilefish to bear, had caused the catastrophe. For years it was feared that the species had been exterminated, but gradually it reestablished itself and is again abundant.

Tilefish

(*Lopholatilus chamaeleonticeps*)

Usual Length, 18 to 24 Inches

This fish has no near relatives within its range, which is rather circumscribed for such a large fish. It may be defined briefly as lying along the outer edge of the continental shelf off New England to opposite the Virginia Capes, in water varying from about 50 to 200 fathoms. Commercially the tilefish is taken from Massachusetts to New Jersey. A maximum weight of 50 pounds is attained, but fish weighing even as much as 35 pounds and having a length of 42 inches are unusual.

The tilefish is brilliantly colored, with the upper parts of the side bluish or olive green, a color that blends into yellow or rosy on the lower part of the sides. The head is tinged with red on the sides, and pure white below. The upper part of the sides are thickly dotted with small yellow spots, which extend on the fin on the back. The peculiar flesh fin over the head, which no other local species possesses, is greenish yellow. It is on the whole the most gorgeously decorated marine fish in northern waters, rivaling the beautifully colored coral reef fishes of the tropical seas.

There is no greater wonder story of the seas than the history of the tilefish. Today a few connoisseurs pronounce it second only to pompano in flavor.

Prior to 1879 this fine fish had no place in the roster of known fishes. In that year a New England trawler, fishing for cod off the Nantucket coast, took 5,000 pounds of tilefish, the first of which there is any record. Whether eaten fresh, salted, or smoked, the samples the trawler took home proved attractive.

For three years there was widespread interest in this newly found food fish. Then, in April and May, steamers arriving from Europe reported seeing myriads of dead tilefish. One steamer reported that it had sailed through 150 miles of them, and data gathered indicated that perhaps 7,000 square miles of sea surface was strewn with the victims of some untoward circumstances of the sea. It was estimated that the total number of dead fish might reach a billion and a half.

There were no signs of disease and no evidence of parasitic infection. Neither could the calamity be accounted for on the basis of attack by other creatures.

All sorts of theories were advanced to explain the catastrophe—submarine volcanoes and poisonous gases among them.

It had been noted, however, that there was a strip of water, lying on the border of the Gulf Stream slope, between the Arctic current and the cold depths of the sea, which was warmer in 1879 and 1880 than the normal water of that region. Dredging in this water had revealed many species of marine invertebrates

characteristic of the waters of the lower latitude, a sort of tropical faunal peninsula in the sea.

In 1882, after the vast schools of tilefish had disappeared, this region was resurveyed. It was found that the water was colder, and that the marine life that formerly occupied this thermal peninsula had disappeared. What had happened was that northern gales had driven Arctic ice down into the area and had made the water too cold for the tilefish to bear.

It was predicted that if this were the correct explanation, and if the water came back to its usual temperature again, the tilefish would ultimately reappear. But years went by and not a single survivor of the catastrophe was found. Fears began to be entertained that the species had been wholly exterminated by the calamity that had befallen it.

But in 1892 the *Grampus* caught eight. Increasing catches with successive years showed that the tilefish was gradually reestablishing itself, just as the scientists had predicted it would.

But after the tilefish appeared again, the task arose of introducing it to the dining table of the American people. Possessed of a flesh of fine texture and good flavor, it faced a difficulty only in the inertia of the people against trying new kinds of food. The United States Bureau of Fisheries, however, undertook propaganda in favor of the tilefish and met with fair success. For awhile it was the most advertised fish in American waters. At present it has to rely on its flavor to carry it to a wider popularity among a clientele somewhat disinclined to try new things.

No further disasters have occurred, and the yield of the fishery has fluctuated no more than that of many other marine fishes during the last 25 years. The total catch in 1935 was 2,655,000 pounds, mostly taken off New York and New Jersey.

The tilefish apparently is strictly a bottom fish, perhaps seldom, if ever, rising to the surface. Furthermore, it seems to reside on the same grounds throughout the year. Its food consists of a great variety of bottom-dwelling invertebrates. Among them crabs are the most important article of diet. Squids, shrimps, shelled mollusks, annelids, sea urchins, sea cucumbers, and anemones are also eaten. Occasionally fish are eaten, as dogfish and eels; and unidentified fish bones have been found in tilefish stomachs. Tilefish are caught on trawl and handlines. Any kind of bait is taken, though menhaden are preferred.

Spawning takes place during mid-summer, certainly during July and August, the beginning and the end of the season not being definitely determined. The eggs are buoyant, and are about 1.35 millimeters in diameter. The larval stages have not been seen and nothing is known of the rate of growth, nor of the age at which tilefish mature.



Painting by Hashime Murayama

STRICTER MEASURES OF CONSERVATION HAVE HELPED TO HALT THE DECLINE OF THIS UNGAINLY TRIBE

The **American Lobster** inhabits rocky and sandy bottoms along a coastal strip 30 to 50 miles wide. It ranges from Labrador to North Carolina, but has been taken in recent years chiefly from Massachusetts northward, being most numerous on the shores of Maine and Nova Scotia. Maine now has a law prohibiting the capture of both the small and large individuals, in addition to the older statute forbidding capture of females carrying spawn.

American Lobster

(*Homarus americanus*)

Usual Length, 8 to 12 inches

The American lobster, so called to distinguish it from its near European relative (*Homarus vulgaris*), is found from Labrador to North Carolina in a shore strip 1,300 miles long, if measured in a straight line, and 30 to 50 miles wide. It is not taken in any considerable quantities south of Delaware, and during recent years chiefly from Massachusetts northward.

It inhabits waters from the shore out to the 100-fathom line and is most numerous on the shores of Maine and Nova Scotia. It prefers rocky bottoms, though it may be found in other environments, and usually, though not without exception, leaves the shallower waters during the winter months and finds temperatures more to its requirements beyond the 100-fathom line.

All kinds of animals, both living and dead, and some vegetable matter are pleasing to its appetite. Although dangerous prey to attack, the lobsters, in spite of their hard shells, powerful claws, and burrowing habits, fall victim to the cod, the tautog, the skate, and the dogfish, which annually destroy millions of them, particularly the young ones, the egg-bearing females, and the molting adults.

The Pilgrims and Englishmen who began to flock into the settlements in Massachusetts in about 1630 were well acquainted with the lobster in their old homes in England. The American lobster was so much like the one "at home," only much more numerous, that it was accepted as an old familiar article of food. It was utilized, therefore, from the beginning. The fishery as a separate industry was first developed in the region of Cape Cod and Boston toward the close of the eighteenth or the beginning of the nineteenth century. Strangely this industry did not spread to the coast of Maine, where it subsequently attained its greatest proportions, until about 1840.

The expansion of the lobster fishery continued with the years as the demand increased, with little thought of "the tomorrow." In 1892 the fishery in the United States yielded 24,000,000 pounds, valued at \$1,062,392. Thirteen years later, in 1905, the annual yield had fallen to 11,898,000 pounds, valued at \$1,364,921. In this short time the supply had been cut approximately in half, though the value had increased greatly.

Presumably because of the institution of some useful measures of conservation, no further pronounced decline in the catch has taken place during recent years. The total yield for the United States in 1935, which was 10,835,000 pounds, valued at \$3,403,000, actually was higher than in some earlier years.

The effect of overfishing for lobsters shows more in the steady decline in the size of those

taken than in the diminution of numbers. The provision of a closed season does not accomplish much, since the female carries her spawn attached to her body for about ten months. Regulations requiring the release of females carrying spawn—"in berry," as that condition is known to the lobster fishermen—have been made, but are usually ineffective.

The number of eggs produced by a female lobster varies from 3,000 to 100,000, depending upon the size and age of the individual, maturity being reached in from three to four years. It is believed that a female lays only every other year.

The lobsters are usually caught in traps known as lobster pots, made of ordinary plastering lath and having a funnel-shaped opening made of tarred netting, permitting easy ingress, but closed against exit. The traps are sunk on lobster-frequented grounds and baited usually with pieces of stale fish. The European variety seldom reaches a weight of 10 pounds, but those of our shores occasionally weigh as much as 25 pounds. The largest one ever taken, according to the records, weighed 34 pounds.

The lobster is enclosed in a hard chitinous shell, which does not increase in size as the animal grows. Therefore, it has to molt, that is, cast off its old shell and acquire a new one periodically, in order to grow. Its size, or rather its rate of growth, therefore, is measured by the number of times it has molted, for molting occurs very irregularly, depending upon the amount of food available, on temperature, and perhaps on other factors. For these reasons some molts follow in close succession and others at longer intervals.

The newly hatched larvae are very different from their parents, and pass through four successive stages before acquiring a resemblance to the adult. The larvae at hatching are 7.8 millimeters long, and after they reach the fourth stage they have grown only to a length of about 12.6 millimeters. At one year of age, when they have molted 12 times, they are only $2\frac{1}{8}$ inches long, at two years only a little more than 4 inches, at four years 8 inches, and at six years 11 inches long.

Subsequent growth is slower, but it does not cease. It has been estimated that a lobster $19\frac{1}{4}$ inches long is 20 years old, and one $22\frac{3}{4}$ inches long has attained the age of 33 years. If these estimates are correct, and if the increase in the rate of growth decreases progressively with age, as would be expected, the giants that have been reported, weighing from 25 to 34 pounds, must have been very old. The largest one of all, which is mounted in the American Museum of Natural History, in New York City, and which had a weight when fresh of 34 pounds, and a length (without the claws) of $23\frac{3}{4}$ inches, must, according to Herrick "have possibly weathered the storms of life for a half century or more."

The Following Five Plates Portray Some Prominent Species of Our Middle and South Atlantic Coastal Waters

Gray Squeteague

(*Cynoscion regalis*)

Usual Length, 16 to 24 Inches

This species, though nearly always listed in books as squeteague, is much more widely known in the field as weakfish, or as trout, with a modifier to distinguish it from its relatives. Its wide range extends from Massachusetts Bay to Mobile, Ala.

An authority on New England fishes listed it from there as weakfish; an equally good authority listed it as weakfish from New York also; and from Chesapeake Bay southward it is known only as trout or gray trout. It is not related, however, to the salmon and the trouts of our fresh waters.

This fish has two rather near relatives within its range. The one is the spotted squeteague, or spotted trout (*Cynoscion nebulosus*), a food-fish of great commercial importance, which ranges from New York to Texas. The other one is the bastard, or silver, trout (*Cynoscion nothus*), a fish of minor importance found from Chesapeake Bay to Texas.

The squeteague or seatrouts are excellent food fishes, and are always in demand. The gray squeteague is said to reach a maximum weight of 30 pounds. However, fish weighing as much as 16 to 18 pounds are rare. The usual weight of market fish is only about one to three pounds.

This fish enters bays, sounds and estuaries from March to May, and remains until about November or December when it presumably withdraws to deep water to escape the low winter temperature of shallow water. A season of scarcity occurs within a month or so after the fish arrive in the shore waters. At this time many of the large mature fish run out to sea to spawn. The best fishing seasons are spring and fall.

This squeteague is most abundant from New York to North Carolina, and within this range it is unsurpassed in importance to the small fishermen who have nothing more than small power boats and seines. Large quantities are caught along the shores in haul seines. It is taken also with pound nets, and otter trawls. Some are caught on hook and line, principally for sport. The total annual catch in 1937 was 31,128,000 pounds.

The principal spawning period begins in the spring, and continues into the summer. Most of the eggs are cast out at sea, though some spawning takes place in the larger bays and sounds. The eggs are buoyant and transparent, and average about 0.84 millimeter in diameter. Hatching occurs in about 12 to 14 hours at a temperature of 68° to 70° F. The newly hatched larvae are about 1.75 millimeters long.

The rate of growth during the first year of life is fairly rapid. When about 14 months old, the fish average eight inches in length, and it seems quite certain that many of the fish reach a length of 12 inches or more, and sexual maturity, at two years of age.

Striped Bass

(*Roccus saxatilis*)

Usual Length, 12 to 24 Inches

The striped bass, also known as rockfish, has a wide range, occurring along the coast all the way from the St. Lawrence River to Louisiana. It is able to endure both high and low temperatures. Introduced in California in 1879, it now ranges on the Pacific coast from southern Washington to southern California.

The striped bass stays near shore in salt, brackish, and fresh water. Very few have been taken out at sea, nor do they ordinarily run far up fresh water streams. So far as known, they spawn only in fresh water, preferring streams with swift currents. This bass is not so strictly anadromous as the shad, alewives, and salmons; even the adults frequently occur in fresh water when not spawning.

A great size sometimes is attained, a maximum weight of 125 pounds being recorded. However, the great majority of the fish sent to market weigh less than 15 pounds.

The striped bass is strictly carnivorous, feeding principally on fish, crustaceans, annelid worms, and insects.

The striped bass is an excellent food fish, and is always in demand. Like more than a few other commercial species, it has gradually become scarcer along the Atlantic coast. It has declined less in the Chesapeake Bay States and North Carolina, where the greater portion of the fish now are caught, than northward. The total annual catch on the Atlantic, in 1937, was 3,235,000 pounds. The catch on the Pacific coast in 1936 amounted to 29,000 pounds. The fish are caught with pound nets, gill nets that may be submerged or set adrift with the current, haul seines, and other sorts of traps. Its value is greatly enhanced because it can be taken both in summer and in winter.

Spawning takes place from April to June. The eggs are about 3.5 millimeters in diameter, and hatch in 48 hours at a temperature of about 65° Fahrenheit. The newly hatched fish is only 2.5 millimeters long. The rate of growth is only moderately fast, the average length of the young being four inches at one year of age; 10 inches at two years; 15 inches at three years; and 18.5 inches at four years of age. Sexual maturity is attained by the males at three years, and by the females at four.



Hashime Murayama

Painting by Hashime Murayama

FIT FOR A KING'S TABLE ARE THESE HANDSOME ATLANTIC COAST NATIVES

From March to May, the **Gray Squeteague**, also called sea trout and weakfish (upper left), seeks shallow waters and remains until November or December. It ranges from Massachusetts to Alabama, but is most abundant from New York to North Carolina. A shore-lover found along the coast from the St. Lawrence River to Louisiana, the **Striped Bass** or rockfish (below and right) spawns from April to June in fresh-water streams.

Sea Bass

(*Centropristes striatus*)

Usual Length, 10 to 15 Inches

The common name shows clearly enough that this species is a member of a large family, the sea basses, the majority of which live in tropical and subtropical waters. Many sea basses reach a fair to a large size, are fine food fishes, and enter commerce extensively. Some of the species are too small or too rare, however, to be of much direct value to man.

The common sea bass, which is often known as black will, in the Chesapeake region, and almost always as blackfish in the southern states, ranges from Massachusetts to the Atlantic coast of Florida. Within its range it has only one near relative. To this one it is so closely related that fishermen generally do not distinguish the two. The second species, which is known to science as *Centropristes philadelphicus*, has received no distinctive common name. This related species is known from North Carolina southward, and enters the commercial catch in limited numbers only in South Carolina and Florida.

The sea bass is found on rocky or rough bottom, and among piles, along breakwaters, and around old wrecks. The chief fishing grounds are located off the coasts of North Carolina, Delaware, New Jersey and Long Island. The fish are so strictly confined to the surroundings named that it is useless to fish for them elsewhere.

The important sea bass grounds of North Carolina, some 20 to 30 miles off the coast, in 20 to 30 fathoms of water, have a hard rough bottom, composed principally of dead and broken coral. As long as the fishing vessel is over this kind of bottom, fish are taken in abundance. In fact, the commercial fisherman, who always operates two hand lines simultaneously, each line being provided with three hooks, is kept very busy drawing in one line, removing the fish and rebaiting it, while the other is overboard. Often two hooks, and sometimes all three, hold a fish. However, as soon as the vessel drifts beyond rough bottom, biting ceases.

That this fish is principally a bottom-feeding fish is clear from the habitat described. It feeds on all sorts of animals of suitable size occurring on the kind of bottom frequented, and at times it includes plants. The stomachs of the sea bass nearly always are gorged with food, so much so that it is advisable to dress the fish very soon after catching them to prevent decomposition, and unpleasant odors from the stomach contents. Its principal foods are crabs, mollusks, shrimp, fish, isopods, and amphipods, named in order of apparent importance.

A voracious biter, the sea bass is nearly always ready to take any bait offered. In the pursuit of the off-shore fishery in North Caro-

lina, the fishermen provide themselves only with enough bait to start the catch. Generally the bait consists of a few fish of whatever sort is obtainable most conveniently. These are cut into blocks of suitable size. When that supply of bait is used up the fishermen continue fishing with pieces of some of the sea bass already caught. For inshore fishing, as along breakwaters, where the fish are less numerous, and apparently less greedy, fiddler crabs, and hermit crabs are excellent bait.

Sea bass are caught extensively for sport also. The magnitude of sport fishing along the New Jersey coast, where the sea bass is taken from May to November, is truly remarkable. Seagoing power boats carrying as many as 4000 persons, principally from New York City, visit the fishing banks daily.

A maximum weight of seven and a half pounds is attained, but fish weighing more than five pounds are rare. Southward the fish seem to run rather smaller in size than northward. The majority of the fish taken from Chesapeake Bay southward probably weigh less than a pound and do not average more than a foot in length. The meat of the sea bass is white, has a fine flavor, and is always in demand. It is taken in commercial quantities almost throughout its range, or at least from Cape Cod to Florida. The annual catch according to the latest statistics available was 5,958,000. The comparatively large quantity of fish taken by sportsmen, of course, is not included in the amount given, which covers the commercial catch only.

The fish are caught largely with hand lines and, during recent years, with otter trawls, and a few with pound nets. Southward, at least, the fishery could not stand a much heavier drain. To date the fishery is pursued principally during the winter. Though the bass withdraw from the shallowest shore water during the coldest part of the winter in the southern States, as they do to a greater extent and for a longer period of time northward, they are available, at least in North Carolina, in abundance on the offshore grounds.

A considerable winter fishery has been developed off the Virginia Capes since 1930. Here the fish are found during mild winters, in 30 to 40 fathoms of water. However, during very cold weather the water gets too cold for them at this depth and they are forced off shore to depths so great that they cannot be reached with the otter trawls.

It seems highly probable that some of the bass from farther north migrate to this general vicinity for the winter.

Spawning takes place in May on the North Carolina coast, and from the middle of May to the end of June off New Jersey, Long Island, and southern New England. The eggs, pelagic and about one millimeter in diameter, hatch in about 75 hours at a 60° temperature.



Hashime Mui'ayama

Painting by Hashime Mui'ayama

NEAT DRESSER IS THE SEA BASS WITH TWEEDLIKE SUIT OF STRIPES AND CHECKS

While the **Sea Bass** is found from Massachusetts to Florida, it abounds especially from Montauk Point, Long Island, to North Carolina. It frequents rocky or rough bottoms and is also found among piles, along breakwaters, and around old wrecks. The average size of the species is two pounds or less. Sea bass are caught extensively for sport, particularly along the New Jersey coast where New York anglers by the thousands fish from seagoing power boats.

Bonito

(*Sarda sarda*)

Usual Length, 18 to 24 Inches

The bonito belongs to that eminent family of fishes, the mackerels. Among its cousins are the common mackerels, the frigate mackerels, the tunnies, the albacores, and the kingfishes. On the Pacific coast it has some very near relatives, one of which was once taken off Rhode Island.

It lives mainly in the open sea, widely wandering in vast schools and approaching land only in search of food or for spawning. Its summer range is from Maine to Cape Sable, Florida; it is also found in the Gulf of Mexico, and on the European coast from Scandinavia to the Mediterranean Sea. It sometimes reaches a length of two to three feet, and a weight of ten to twenty pounds; but usually does not exceed six pounds.

The flesh of the bonito often passes as Spanish mackerel, though it is far inferior to that fish in edibility. In the Chesapeake Bay region it is often sold as "Boston mackerel," that is, as the northern mackerel (*Scomber scomberus*).

The late Professor Goode called the bonito a marvel of strength and beauty, and asserted that it is one of the ocean's fastest swimmers, being built on such fine stream-line proportions, and having such a polished-surface body that water resistance is brought down to negligibility. "The bonitoes," said he, "in our sounds today may have been passing Cape Colony, or the Land of Fire day before yesterday," so fast can they glide through the water.

The bonito is a fine game fish, and is caught by trolling, like the bluefish, the Spanish mackerel, and the kingfishes. It is a powerful animal and puts up as good a fight as any other fish of its size. Commercially it is taken also with pound nets, occasionally with haul seines, and now and then with purse seine.

It is very erratic in its appearance along the shores, and there is consequently a great fluctuation in the annual catch. The total annual yield for the Atlantic coast of the United States, according to the latest statistics available in 1934, was 308,000 pounds, one of the lowest catches on record. Only a year earlier the records show a yield of 1,147,000 pounds. The annual catch no doubt could be greatly increased, if a special effort were made to seek out the schools. The species is of comparatively little commercial value, however, and generally is taken more or less incidentally in connection with other fishing operations.

The bonito is a highly predatory fish feeding on smaller schooling fish, such as menhaden, alewives, and mackerel. Concerning its life history almost nothing is known, except what already has been stated. Though it is supposed to come inshore to spawn, its eggs and

the larvae remain unknown. It is truly remarkable how little has been learned about this common fish, which has been known to science since 1793.

Bluefish

(*Pomatomus saltatrix*)

Usual Length, 15 to 24 Inches

The bluefish stands alone in its family, which has as its nearest relatives the pompanos. It is a gracefully shaped fish, being somewhat deeper than broad, with a rather long head, large mouth, and forked tail. Its color above is deep blue, which shades into the green along the side, and the green shades into the silvery color of the belly. It is evident, then, that the bluefish gets its name from its color. Small fish are called "tailors" in some localities, and the names "snapping mackerel" and "greenfish" are heard.

The bluefish is of very wide distribution, occurring in the warmer parts of the Atlantic and Indian oceans. On the Atlantic coast of America it ranges from Maine to or beyond Venezuela. On the coast of the United States it is taken in commercial quantities from Massachusetts to Alabama.

Bluefish are highly predatory. They form schools and follow and feed on smaller schooling fish. They are terrors among smaller fish. After they have fed to their fullest capacity they continue the destruction, killing many more than they can eat.

This very valuable fish declined in abundance over a rather long period of years, until it was thought that the decrease was permanent, presumably because of over fishing. The annual catch according to the statistics available in 1908, was 16,575,000 pounds. By 1928 it had dropped as low as 3,559,000 pounds, but by 1937 it had increased to 9,673,000 pounds. The increase in the catch since 1928 offers some hope that the fish may be coming back in their former abundance. The decline over a period of years, therefore, may have been only a periodical fluctuation, a phenomenon not unusual among marine fishes.

It is remarkable how little is known about the life history of this common fish. It is believed to spawn off shore during the summer, since the larvae have been found some distance at sea. The eggs remain unknown. Neither has the rate of growth nor the age at which the first spawning occurs been determined.

A maximum length of 3 feet 9 inches, and a weight of 27 pounds is known to be attained. Fish weighing 10 to 15 pounds occasionally are caught, but the general run of market fish range in weight from about one to four pounds. In the northern part of its range the average size of bluefish is greater than it is southward. This unexplained phenomenon is true also of several other important food fishes.



Hashime Murayama

Painting by Hashime Murayama

RUTHLESS PREDATORS OF THE HIGH SEAS ARE PRIZES IN ANY ANGLER'S CATCH

A member of the mackerel family, the **Bonito** (top) wanders in vast schools. This species is found from Maine to Cape Sable, Florida, and in the Gulf of Mexico, reaching a weight of 10 or 12 pounds, although a fish of more than six pounds is exceptional. One of the ocean's fastest swimmers, it is a powerful fighter. The graceful **Bluefish** (lower) ranges the warm parts of the Atlantic and Indian oceans. Both these fish are terrors of smaller schooling species.



Photograph by H. Armstrong Roberts

AN ANGLER YIELDS TO THE ENCHANTMENT OF THE CATARACT

He pauses before the glittering spectacle of Wilmington Falls, Ausable River, in the Adirondack Mountains of New York. Pools above and below the chutes offer trout angling amidst striking surroundings. Several hatcheries in this region continually restock the heavily-fished streams.



Photograph by H. Armstrong Roberts

ANKLE-DEEP IN THE FOAM, A SURF FISHERMAN UNHOOKS HIS CATCH

A powerful surf caster can hurl his bait more than 400 feet. There are several methods of casting from an ocean beach. It is well to give the angler plenty of room, as the wickedly-flashing, weighted hook may sweep a considerable radius. A red drum is the plump prize here.



Hashime Murayama

Painting by Hashime Murayama

MULLETS (UPPER) HOLD THE CENTER OF ATTENTION AT MANY A SOUTHERN FISH-FRY

When eaten very fresh, the **Striped Mullet** (above) is a table fish of good quality. One of the most abundant and valuable of all Atlantic food fishes, it collects in vast schools along the southeastern shores of the United States in autumn. It is found on both coasts of both the Atlantic and Pacific oceans. A food and game fish of high rank, the **Sheephead** (lower) ranges from Cape Cod to Tampico, Mexico.

Striped Mullet

(*Mugil cephalus*)

Usual Length, 8 to 15 Inches

Few other species of fish have as wide a distribution as the striped mullet, which may be called a cosmopolitan fish. It is found in Japan and Hawaii, and on the Pacific coast of America from Monterey to Chile. It occurs also on the coast of southern Europe and northern Africa, and on the Atlantic coast of America from Cape Cod to Brazil. In some localities it ascends fresh water streams, fish having been taken more than a hundred miles from the sea.

In the northern part of its range, as from Chesapeake Bay northward, this mullet is present along the shores only during the summer. Though it remains in shallow water more or less throughout the year on the southern shores of the United States, the principal "run" occurs in the autumn. At that time great schools collect along the shores. Whether the fish then are on a southward migration has not been determined. The fish in any one school are of nearly uniform size, and therefore probably of the same age. Schooling begins early in life, as fish only an inch or so long often are seen in schools.

Mullets do not prey on other fish, but feed on microscopic organisms, such as diatoms and Foraminifera. Often they feed at the surface, thereby betraying their presence, but sometimes they stir up the bottom sediment to acquire food. Their gizzard-like stomachs generally contain much mud.

Mullets have the habit of jumping out of the water, sometimes clearing the surface by several feet. Whether this is a form of play or whether it has some utility in the life of the fish is not known. Two of its several common names, jumping mullet and jumper, it has acquired because of its leaping habit. Another name, fatback, refers to its broad round back.

It makes good use of its jumping propensities in escaping from nets. Considerable skill is required to catch this, our most wary fish.

The mullet is a fine food fish, especially if eaten very fresh. It is a great favorite among the fishermen themselves. The annual catch on the Atlantic and Gulf coast of the United States in 1936 reached the tremendous total of 42,747,000 pounds. The fish are taken mostly with haul seines, though some are caught with gill nets, pound nets, and fyke nets. Great schools sometimes have been caught with purse seines, but that method of fishing for mullets is now illegal in most States. None are caught with lines, for mullets will not bite a hook.

Very little is known about the spawning habits of this common fish. It can be stated

only that it spawns in autumn or early winter. Its eggs and spawning grounds have not been discovered. The rate of growth at first seems to be slow, but much faster after a length of a few inches is attained. Fish five to eight inches long probably are in their second year. Fish only eight inches long often enter into the commercial catches, and are especially good eating. A maximum length of 30 inches is attained in the South where it grows largest, and where 20-inch mullets are not uncommon. It is said that the mullet is the only fish rich enough to be fried in its own fat.

Sheepshead

(*Archosargus probatocephalus*)

Usual Length, 10 to 18 Inches

The sheepshead ranks high as a game fish, being among the gamest of salt water fish. It ranges from Cape Cod to Tampico, Mexico, and rarely to the Bay of Fundy. It belongs to the porgy family. Among its relatives are the scup, the porgies, and the pinfishes.

This fine food and game fish formerly was much more numerous. North of the Virginia Capes it is now comparatively rare. It is most numerous between North Carolina and Texas, the largest commercial catches being made in Florida, Louisiana, and Texas. The total catch for the United States in 1936, virtually all made from North Carolina southward, was 1,217,000 pounds. The fish are caught with seines, pound nets, gill nets, and lines.

Adult sheepshead are found chiefly on rough bottom, among rocks, along breakwaters, piers, and old wrecks. The young at first are pelagic, but soon settle down in shallow areas containing an abundant growth of seaweed. There they remain until a few inches long, when they take up the habitat of their parents. A maximum weight of 30 pounds has been reported, but five to 15 pounds is usual.

Spawning takes place in the spring on sandy shores, late in the evening or at night, a rather usual spawning time for marine fishes. The eggs are pelagic, about 0.8 millimeter in diameter, and hatch in 40 hours in a temperature of 77° Fahrenheit. The larvae have not been described further than that they are small, but active and strong, and withstand considerable rough handling. The young of six millimeters and upward in length have been described quite fully. They acquire the characteristics of the adults remarkably early. Fish scarcely three-fourths of an inch long look so much like the adults that they are easily identified with them.

The rate of growth has been studied only during the first eight months. It is not rapid, a length of only about two and a quarter inches being attained the first summer. The sheepshead has diminished rapidly under heavy fishing, whereas fast growing species have withstood the drain without a serious decline.



Painting by Hashime Murayama

"WEATHER PROPHECY" OF FISHDOM, THE KING WHITING IS SENSITIVE TO COLD SNAPS AND HEAT WAVES

The **King Whiting**, or **Kingfish**, is known along the shore from Maine to Florida, but only during summer does it appear in the more northern part of its range. Off the Carolinas, chilly weather drives it offshore; in warmer weather it frequents the landward shallows. The kingfish, a member of the large croaker family, bears many local names. It ranks high as a food species.

King Whiting or Kingfish

(*Menticirrhus saxatilis*)

Usual Length, 12 to 18 inches

This kingfish belongs to the large family which includes the croakers, drums, spot, and sea trout or weakfishes (Sciaenidae), and it must not be confused with the much larger pelagic kingfishes, which belong to the mackerel family (Scombridae).

This kingfish has two immediate relatives on the Atlantic coast with which its range overlaps. These relatives are so close that fishermen generally do not distinguish the three, and therefore they have no distinctive common names. The group as a whole is well supplied with local or common names. Besides kingfish they are called whiting, king whiting, surf whiting, shore whiting, silver whiting, roundheads, sea minks, and sea mullets. Wherever the three species occur together, the local names apply alike to each.

The common kingfish ranges from Maine to Florida, and is rare north of Cape Cod. One of the other species (*Menticirrhus americanus*) is found from New York to Texas, and the third species (*Menticirrhus littoralis*) ranges from Chesapeake Bay to or beyond Texas.

The kingfish is a shore fish, living principally on the bottom. In the more northern part of its range it is found only during summer. In the Chesapeake Bay it is caught from April to November. From North Carolina southward it withdraws from the shallow shore waters only during cold snaps and reappears as soon as the weather gets somewhat warmer. In North Carolina this species, and at least one other, are taken in considerable abundance along the shores in four fathoms or more of water in late winter and early spring. South of North Carolina the common kingfish is commercially unimportant. In fact, in Chesapeake Bay and North Carolina it is greatly outnumbered by one of the other species (*Menticirrhus americanus*).

The kingfish feeds on shrimps, probably its chief food, crabs, and other crustaceans. It also eats small mollusks, worms, and small fish. So far as known, the diet is about the same for the three species. In some localities the fish takes the hook readily and is a favorite game fish for anglers with rod and reel.

The kingfishes rate high as food fishes wherever they are well known, and there they are in demand and bring a good price. For some reason they are not so well known generally as some other species they far surpass in quality. By far the greater part of the fish now are taken from North Carolina southward. The catch for 1936 was 3,288,000 pounds, one of the largest on record. Only 76,000 pounds of this yield was taken north of Chesapeake Bay. The States with the big-

gest catches were Florida, North Carolina, Virginia, and South Carolina.

As already explained, the species are not separated in the market, therefore, the total catch of king whiting includes all three species. It is known that the northern kingfish (*Menticirrhus saxatilis*) is much less numerous than one of the other species (*Menticirrhus americanus*) in Chesapeake Bay and North Carolina, and that it is commercially unimportant south of North Carolina. Furthermore, it does not occur on the Gulf coast. It follows, then, since only a small part of the catch is made where this kingfish is the predominating species, that this formerly important fish now constitutes only a minor part of the total yield.

The fish are caught principally with haul seines, gill nets, pound nets, and otter trawls. Few if any of the fish taken on lines enter the commercial catches. Virtually the entire catch is consumed in the fresh state.

The spawning period in New Jersey begins in June and continues until August. On the coast of North Carolina spawning begins in March or April and continues through May, and probably into June. It is evident, then, that spawning begins a few months later in New Jersey than in North Carolina and ends correspondingly later.

The eggs are spherical, 0.76 to 0.92 millimeter in diameter, and they float in sea water. They are almost colorless, having only a slight tinge of yellow. Each egg has from one to 18 droplets of oil in the yolk, which makes it buoyant. In nature the eggs are drifted about by the wind and currents; not for long, however, since hatching takes place in 46 to 50 hours at a temperature of 68° to 70° Fahrenheit.

The newly hatched fish is 2.0 to 2.5 millimeters long. The early fry of this species, as of many others, floats on its back for a few days while it is still living on the yolk sac it has retained from the egg. When the larvae right themselves, their mouths are open and they must have food. In case food of the right sort, which consists of microscopic organisms, is not available, the fish will soon die. This is a critical stage in life, and no doubt many of the larvae perish at this time. No one has succeeded in keeping the young alive in captivity through this critical stage.

The rate of growth, during the first summer, at least, is rapid. Some specimens taken at Beaufort, North Carolina, were about four and a half inches long when only approximately three months old. Some of the largest fish of the season taken in Chesapeake Bay in October, when not more than six months old, had attained a length of nearly seven and a half inches, though many of course were much smaller. The rate of growth after the first summer has not been studied in detail.



Photograph by William H. Zerbe

“GOIN’ FISHIN’ ”

OUR HERITAGE OF THE FRESH WATERS

In Fishery Resources of Rivers and Lakes the United States Leads the World

BY CHARLES HASKINS TOWNSEND

Former Director, New York Aquarium

Revised and Extended by Charles M. Breder, Jr., Acting Director, New York Aquarium

SINCE the beginning of time mankind has been able to get some part of his food from the waters; among the relics of the Stone Age are shell hooks and stone sinkers. Ancient sculptures—Assyrian, Egyptian and Aztec—portray the taking of fishes with spear, hook, and net.

The prophet Habakkuk—who knows how many centuries B. C.?—placed some details on fishing in the earliest literature: "They take up all of them with the angle, they catch them in their net, and gather them in their drag."

In some of the far corners of the world amazingly primitive ways of getting fishes are still in use.

In the mountain streams of New Guinea the still-savage native has been found using a dip net made of a hoop fitted with a piece of unbelievably tough spider web.

We have seen the Aleut drag up a heavy halibut with a huge hook of bent wood, the Fuegian make a successful throw with his bone-pointed spear, and the Tonga islander stupefy hundreds of fishes with the juices of a poisonous plant.

The modern Japanese fisher has not yet lost the ancient art of making the cormorant fish for him without the trouble of providing either hook or bait.

OUR FRESH-WATER FISH RESOURCES ARE CONSTANTLY DIMINISHING

In considering the resources of our fresh waters, we find everywhere exhaustive methods of fishing and a diminishing supply, in spite of restrictive measures and extensive fish propagation.

The means by which diminution is measured are to be found in the fishery statistics of the last half century. The annual yield of products—still very large—can be safely viewed only in comparison with the continual increase and improvement in the apparatus of capture.

It takes more and more gear to make the same catch. In the Great Lakes, our

largest reservoirs of fresh-water fish food, the investment in the fishery industry now exceeds \$10,000,000. The principal fish-catching devices, such as pound nets, fyke nets, and gill nets, practically automatic in operation, are filling day and night as long as the Lakes are free from ice.

The rivers and lakes of the United States have fishery resources unequaled elsewhere. The Great Lakes are virtually inland seas, and the navigable rivers are among the largest in the world. The mighty Mississippi, with its tributaries reaching in all directions, fairly dominates the map of the country.

These waters, with the rivers of the Atlantic and Pacific coasts and many lakes of the northern States, have been enormously productive in food for our people.

TONS OF FOOD FROM GREAT LAKES

In 1937, commercial fishermen alone took from the Mississippi River and its tributaries more than 80,000,000 pounds of fish, and the Great Lakes yielded almost 85,000,000 pounds.

Large as are the food supplies of these two regions at present, they must have been vastly greater before the exploitation of their resources began. Unfortunately, there are no official records by which the extent of the earlier fishery operations may be measured.

While the fish food derived from our fresh waters is vast in quantity, it is also notable in variety. There are many kinds of trouts, salmons, whitefishes, sturgeons, pikes, basses, sunfishes, perches, catfishes, the shad, and the eel, as well as the less important, but abundant and widely distributed, chubs and suckers.

In addition to the familiar food and game fishes, our waters are rich in minnows, darters, shiners, and other small fry of no direct economic value, but of vast importance as the food supply of larger fishes. Every great watershed has its peculiar forms of these, all well known



Photograph by Edwin L. Wisherd

A SEVEN-FOOT ALLIGATOR GAR LOOKS FORMIDABLE

Such enormous predacious creatures abound in the waters of Louisiana and destroy many valuable food fishes.

to ichthyologists, who have described and named them by the score.

Some of our smallest fishes have been found useful in combating malaria and annoyance caused by mosquitoes, and are even being shipped by the United States Bureau of Fisheries to mosquito-plagued foreign countries. There is now in progress much active investigation regarding the value of several species of fishes for the control of the mosquito.

UNITED STATES HAS FIVE TIMES AS MANY KINDS OF FISHES AS EUROPE

The richness of fish life in our fresh waters is amazing. The United States has a smaller area than Europe, yet it

has nearly five times as many kinds of fresh-water fishes. We have about 585 species of these, while Europe has only 126 species.

We find that a single State may have considerably more than 100, the number known to Illinois being 150, while New York is credited with 141. It could doubtless be shown that our fresh-water fishery resources are greater than those of any other country.

Many of the fishes commonly taken for food or in sport fishing, and naturally of wide distribution, have been established, as a result of fish-cultural operations, in sections of the country far removed from their original habitat.

A fish belonging to the Mississippi system or to the Atlantic slope often takes full possession of a new watershed, in consequence of mere transplantation of limited numbers.

Although the numbers of fishes caught by anglers do not figure in statistics of the catch made for market, they

are not without high economic and other values. Most of the northern States are visited in summer by tourists interested primarily in good angling waters.

Lakes far and wide have become summer resorts for people who find much of their recreation in fishing. Railways and summer resorts widely advertise the resources of their waters. Summer visitors, moving actually by hundreds of thousands, carry into these States millions of dollars. The trade in angling equipment alone is extensive.

Who can measure the health and esthetic values attendant upon the angling idea? The angling habit seems to be conducive to long life, and, beginning with Izaak

Walton, who lived to be ninety, presents a long list of celebrated fishermen who lived well into the eighties and nineties, many of them prominent in the literature of American angling.

Fresh-water fish culture in the United States has been carried on for more than fifty years in steadily increasing volume, in the effort to keep pace with a depletion by fishery industries which constantly threatens exhaustion of the fish supply.

POLLUTION A DANGEROUS MENACE

The great fishery problem of the time in our country is the pollution of the fresh waters by innumerable agencies, rapidly affecting their productiveness. Unless stern measures are introduced by law to correct this, soon one of our great natural economic gifts will be seriously stricken.

When we consider that the market catch in the Great Lakes alone has sometimes exceeded 100,000,000 pounds in a year, that legions of anglers are overfishing the trout and bass streams everywhere, and that pollution of the rivers by manufacturing industries has reached appalling proportions, it is apparent that our heritage of the waters is endangered to a serious degree.

Fish culture alone cannot save it, even if greatly increased. We are already wasting expensive propagation work in stocking waters no longer suitable for fish life, and many streams have been abandoned to their fate. One could name a score of rivers in mining and manufacturing States, once contributing to the food supply, that now contain no living thing—no fish or mussel or crayfish, not even the air-breathing frog. These rivers represent



Photograph from U. S. Bureau of Fisheries

THE MAGNIFIED SCALE OF A SALMON TELLS ITS AGE

This specimen was taken from a male in its fourth year. The revealing "rings" resemble those of the cross-section of a tree.

damaged resources, and there are others that may soon be like them.

Reforms come so slowly that the great cleaning-up task ahead of the American people is not likely to be undertaken seriously until conditions become intolerable. In many countries all wastes available for fertilization are restored to the land and not sent insensately through sewers into the streams, while manufacturing wastes are converted into valuable by-products. The exhaustion of our fresh-water resources through overfishing and water pollution is not inevitable. A saving fund of knowledge, relative both to propagation and protective measures, now awaits application through the force of public demand.



Photograph by Kenneth M. Wright

THIS TIME THE BIG ONE DIDN'T GET AWAY

This catch of pike was hooked at Ten Mile Lake, Minnesota. They are voracious fighters and eat quantities of fish.

A more recent but increasing danger to which angling waters are exposed lies in the ever-increasing use of the automobile. Bass and trout waters heretofore reached with difficulty have become the easily accessible resorts of camping parties, with the result that their resources are being exhausted.

Many as are the sportsmen taking toll of our wild life with the gun, those who use the rod are vastly more numerous. It is as easy to exhaust a small stream by overfishing as it is to exhaust the quail supply of a neighborhood. Fortunately, the preservation of the fishes is always possible through the employment of safeguards and restorative measures. Our fish-

ing will doubtless last longer than our shooting.

Private fish culture would be of great service in maintaining and increasing our supply of fish food. Although it has been practiced for centuries in some European countries, it has but little more than commenced in America.

The possessors of strongly flowing springs, brooks, and small lakes should be awakened to the value of their home resources for water farming. Approved methods for the construction and management of fish ponds have been worked out at public fish-cultural stations and instructive public documents on the subject can be had for the asking.

Fish-culturists assert that an acre of water can be made to yield more food than an acre of land, and the truth of the assertion has been demonstrated.

**MUSSELS DEPENDENT
UPON FISH HOSTS**

An interesting work in aquiculture is now being carried on in the Mississippi Valley under the direction of the Bureau of Fisheries. It is based upon the fact that the propagation of the mussel is dependent upon the presence of fishes to which the young, free-swimming mussels may attach themselves as parasites until they are old enough to form shells and begin an independent existence.

The large, heavy-shelled mussels of this region have been gathered in such numbers for the manufacture of pearl buttons, and also for the valuable pearls they sometimes contain, that the supply is being exhausted and the important industry dependent upon the mussel is in danger.

The mussel industry annually yields about 20,000 tons of shells which are worth

almost half a million dollars. We are all wearing pearl buttons from this source, which will be missed if the great river becomes too foul for the growth of mussels.

Young mussels attach chiefly to the gills of fishes, and in some species to the fins, during the early period of their lives. It is now certain that all mussel spawn which fail to find a suitable fish host sink to the bottom and die.

The young mussels are temporarily provided with minute hooks for attachment and are soon enveloped in the epithelium of the fish, where they remain encysted until the shell begins to form and they can safely drop off.

Not all fishes are equally susceptible to these temporary mollusk parasites; some receive very few, others shed them too soon, while still others die as a result of carrying too many. Practical work is in progress, and large numbers of fishes "infected," as it is called, with young mussels are liberated to stock the public waters, as their "parasites" develop and fall off.

TURTLES, FROGS, AND CRAYFISH

The "planting" of the mussels is, therefore, left to the fishes. It is even possible to send mussel-bearing fishes to waters outside the Mississippi system and thus introduce the more valuable mussels elsewhere.

There are several species of large turtles of the kinds known as "sliders" in our fresh-water streams and lakes, especially in the Middle and Southern States, that contribute to the food supply. They have long been used in filling the ever-widening vacancy in the markets formerly occupied



Photograph by S. N. Leek

A SON OF WYOMING WINS WITH TWO OF A KIND

The fish shown here are one of the numerous species of the Rocky Mountain region—probably the Yellowstone trout (*Salmo lewisi*).

by that favorite of the epicure, the diamond-backed terrapin of the salt-water marshes.

They have so high an edible value that it is whispered we often pay terrapin prices for turtles that never saw brackish water. Fishery officials are aware of their importance and have studied their distribution, methods of capture, and conservation.

Frogs of several kinds are valued aquatic food delicacies, and their habits have received considerable attention with the view to developing a practical system of frog-culture. It is to be hoped that some practicable and efficient method of conservation will be found before the natural supply approaches the point of exhaustion.

The annual market supply of freshwater turtles and frogs has been known to exceed half a million pounds of each, the great bulk of the catch being derived from the Mississippi and its tributaries.

FOODS OF FISHES

A subject of perpetual interest to all who fish with the rod is the food of fishes. There are moments in the lives of all of us when the most important thing in the world seems to be how to get the fish to bite. The problem is taken as seriously by the captain of some great industry, off on a fishing trip, supplied with the most expensive tackle, as by the barefooted urchin with a homemade pole, and doubtless the man of business is the more serious of the two.

Thanks to the patient laboratory investigations of Professor S. A. Forbes, this dark question has been made luminous. He tells us that while the food of fishes consists chiefly of other fishes, it includes virtually the whole aquatic fauna—a comfort when we would seek for baits.

Fishes not only feed on other fishes and on insects, but on crustaceans, mollusks, and worms. Plants do not constitute much of their food, although a few kinds feed on them, such as buffalo-fishes, carps and minnows. Some fishes get food by rooting in mud, while others are inclined to be scavengers.

Among the chiefly fish-eating fishes may be mentioned pike, pickerel, muskellunge, pike-perch, burbot, gar, black bass, and channel catfishes. Those taking fish food in moderate amounts are represented by bream, blue-cheeked sunfish, mudfish, white bass, rock bass, and crappie.

Fishes which feed on other fishes to a trivial extent are white perch, suckers, spoonbill, the various darters, top minnows and silversides, sticklebacks, mud minnows, stone-cats, and common minnows. The whole minnow tribe contributes to the food of the smaller fish-eaters.

In the Mississippi region the gizzard-shad constitutes 40 per cent of the food of the wall-eyed pike, 30 per cent of that of the black bass, half that of the pike, and a third that of the gars. This is a good illustration of the usefulness of an abundant species of little importance as food for man.

Mollusks—the snails and mussels of various species—are also important as fish

food. They form large proportions of the food of catfishes, suckers, freshwater drum, and mudfish. About 16 per cent of the food of perches, sunfishes, top minnows, and shiners is molluscan in character.

Fishes feed freely on insects, not only on the aquatic forms in their larval and mature stages, but also on terrestrial insects cast into the water in many ways.

Crustaceans appear to be of even more importance as fish food, especially the minute entomostraca. The crayfishes are also eaten.

The food of adult fishes naturally differs greatly from that of the young. In addition to natural foods, both alive and dead, fishes in captivity will devour many kinds of meats and prepared foods. The question, then, as to what constitutes the food of fishes may be answered: almost any living animal forms from the water not too large to be swallowed. Therefore if the fish will not take the bait or the fly first offered, it may be tempted with another, and the resourceful angler need not return with an empty creel.

Little can be learned definitely about the ages attained by fishes, unless individuals are kept under observation in captivity.

AGE, GROWTH, AND HABITS OF FISHES

The records of public and private aquariums, however, furnish data that we may consider reliable. The European eel has undoubtedly lived for long periods in captivity. According to accepted authorities, a few specimens kept in aquariums have lived for periods varying from 20 to 55 years.

Boulenger, in the Cambridge Natural History, states that an eel kept by the French naturalist Desmarest for "upward of 40 years" reached a length of four and a half feet.

It is recorded that four Russian sterlets had lived in the private aquarium of Captain Vipan in Northamptonshire for 25 years. He also had a golden orfe still living after 24 years of captivity. A record from the Brighton Aquarium is that of a sterlet which died after having been kept there "about 38 years."

The Australian lung-fish is known to have lived at the London Zoölogical Gardens more than 19 years.

There are accounts of European trout said to have been kept in captivity for 53



Photograph from Dr. Edward Booth

AMIDST A FLURRY OF SPRAY, A PIKE STANDS ON ITS TAIL

Sometimes big pike leap like salmon. This aquatic acrobat performed for a lucky camera snap in Canada. These fish spawn in streams and shallow lakes soon after the ice leaves.

years, and of carp kept still longer, but such are hardly comparable in verity with the records of existing public and private aquariums.

The New York Aquarium still has specimens (1939) of the mudfish or bowfin and the long-nosed gar which were received in 1903.

In the Aquarium certain North American fishes have lived for long periods: viz., striped bass, 20 years; whitefish hatched in the building in 1913 lived until 1928; large-mouthed black bass, 11 years; muskellunge, calico bass, rock bass, and yellow perch, 10 years. The last four were adults when received and are still living.

A striped bass kept in captivity for 19 years weighed 20 pounds and was three feet long when it died. Its length when received was about six inches. This species sometimes attains a weight of 80

pounds or more. It is likely that some species grow faster in freedom, where they find their natural foods, but other kinds may develop faster in suitable ponds, where they are well cared for and protected from enemies.

TELLING THE AGE OF A FISH BY ITS SCALES

Wild fishes of exceptionally large size being often found, we may assume that fishes continue to grow through life, the period of life depending largely upon enemies. In a world beset with sharp fangs and claws, the life of a wild animal, either in the water or on land, is apt to end in a tragedy.

It is now known that the scales of fishes bear marks which indicate the length of life and the rate of growth in different years. Studies of the Atlantic salmon in



Photograph by H. Armstrong Roberts

THREE-POUND SPECKLED BEAUTY, NIPIGON RIVER, CANADA

Scotland and of the several species of Pacific salmon have proved this.

The scale grows in proportion to the rest of the fish, principally by additions around its border. The fish grows at different rates during different seasons of the year. Concentric ridges form around the edge of the scale, its marginal expansion in summer being more rapid than in winter, so that the growth during each year is usually distinguishable. (See illustration, page 97).

Studies of the five species of Pacific salmons have shown the ages at which the different species return to the rivers to spawn. Thus, the ridges on a fish's scales are comparable to the annual ring growths revealed on a cross-section of a tree trunk, which tell its age.

Studies of the scales of whitefishes in the Great Lakes have shown that the scale characters are so well defined that they indicate the age of the individual fish and the rate of growth of the species.

Scales from whitefishes hatched and reared in the New York Aquarium and therefore of known age have been used by Government biologists in checking the results of studies of the scales of wild fishes.

The sexes of fishes are not so readily distinguishable as the sexes of birds. Males and females are usually so much alike that only the expert recognizes the differences, and in many species the dissecting knife must be employed to determine the sex.

The colors of fishes vary somewhat according to the waters which they inhabit, and this applies also to fishes held in captivity, where their colors tend to become more subdued. The fishes of exhibition tanks, however, brighten

their colors during the spawning seasons, much as do wild fishes.

The habits of fishes have not been studied so thoroughly as those of birds, mammals, and other vertebrated animals. Books on fishes are largely of two classes: those written by anglers, relating chiefly to methods employed in the capture of the fish, and those written by the systematic naturalist, dealing chiefly with classification and distribution.

A BIG FIELD FOR SCIENCE

In neither class of books is the life of the fish in its own environment very fully considered. There are, of course, satisfactory life histories of certain common species, especially those inhabiting the smaller streams, and fish-culturists are contributing

new information on the ways of fishes reared in ponds.

Since the keeping of fishes in aquariums became common, many important facts have been recorded, but observations on creatures in captivity can manifestly deal with little of their real life.

For many important facts relating to the senses of fishes we are indebted to the modern biological laboratory. Facts based on scientific experiment relative to fishes' powers of hearing and memory, their color changes, sleep, electrical and poisonous properties, the sounds they make, and so on are slowly being made apparent.

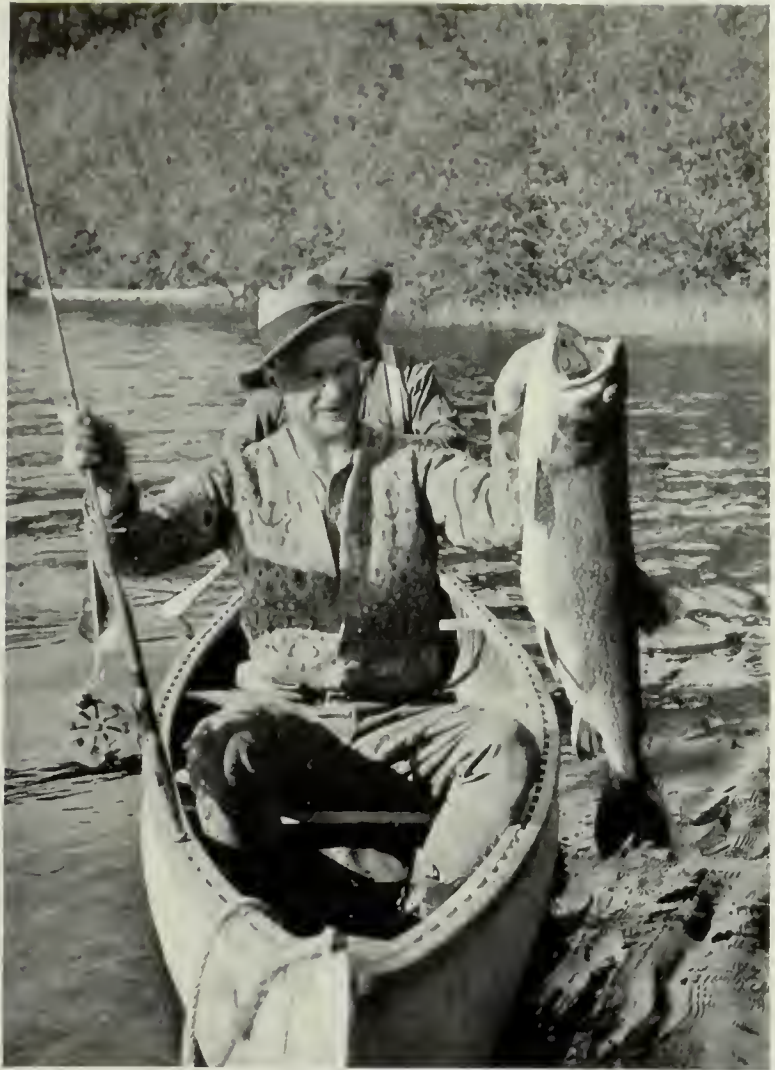
In recent years, scientists have devoted considerable time to the study of the breeding activities of American fresh-water fishes. Odd as it seems, the breeding behavior of salmon and trout was not correctly analyzed until the present decade, even though the spawning activities had attracted the attention of fishermen and naturalists.

Credit for observations and correct interpretation of the spawning activities of brook trout must go to Dr. Albert S. Hazzard; for brown and rainbow trout to Dr. John R. Greeley. Recently, Dr. C. M. Breder, Jr., has clearly summarized the breeding habits of basses and sunfishes.

One of the first and most detailed accounts of breeding habits of fishes was written about twenty years ago by Dr. Jacob Reighard, University of Michigan, with respect to suckers and minnows.

HABITS STILL LITTLE KNOWN

There are a number of papers about other species by several authors, but, as yet, the ecology and habits of most of our commonest fishes are unknown.



"NOW WILL YOU BELIEVE ME?"

Before great headway can be made in the new movement known as lake and stream improvement, the minute details of the habits and life history of each species of fish should be thoroughly understood. To increase the abundance of any game fish, not only the species that it is desired to encourage must be studied, but the habits of forage fishes and other aquatic organisms that enter into the food cycle of the chosen species must also be known.

One of the biggest limiting factors in the rapid growth of game fishes is insufficient food. Thus, to improve lakes and streams, much thought must be put into the physical and chemical factors of the environment.

The naturalist who can devote himself to the observation of the ways of fishes will find a fascinating field and contribute new facts to science.

Blue Catfish

(*Ictalurus furcatus*)

Usual Length, 24 Inches

There are many kinds of catfishes, family Ameiuridae, in the United States, all of which belong naturally to that part of the country lying to the east of the Rocky Mountains, those now abundant in some States west of the Rockies having been introduced.

Catfishes are of considerable importance commercially. The fishery statistics of about 18 years ago show that the annual catch for the market exceeded 14 million pounds, but today the supply is much smaller, only two or three million pounds.

Since they are easy to catch, the total of those taken everywhere with hook and line can only be conjectured, but it may possibly equal the quantity yielded by the commercial fisheries.

Since catfishes in general have the habit of guarding their nests and protecting the young, the supply holds out well in spite of exhaustive fishing. Such habits also as feeding chiefly at night and feeding little in winter contribute to their preservation.

The blue catfish (*Ictalurus furcatus*), inhabiting the Mississippi Valley and now in the Atlantic coast streams, too, is the largest and best of all as a food fish. It occasionally attains a weight of 125 pounds, and 80-pound specimens are not uncommon; however, as is the case with other fishes taken in large quantities, the average weight is only a few pounds.

The blue catfish is less inclined than some other species to live in muddy waters, preferring the clearer and swifter streams. It is a clean feeder, living much on fishes and crayfish. As a game fish it is one of the best in the catfish family, taking many kinds of baits, and is a strong fighter on the line, but never adds to the angler's thrill by leaping from the water. It is said to migrate according to seasonal changes, gathering in the more southerly parts of its range during the winter months.

Channel, or Spotted, Catfish

(*Ictalurus punctatus*)

Usual Length, 20 Inches

The spotted catfish belongs in the Mississippi Valley and the Great Lakes, but is also in the Potomac River, where it was undoubtedly introduced many decades ago. It does not reach the size of the blue catfish, seldom weighing as much as 25 pounds. Like the blue catfish, it is a trim and active fish. There are four species in this genus, all having forked tails. All of our native catfishes have tough, scaleless skins and small eyes, and all have eight barbels or feelers on upper and under sides of the mouth. These are

useful in searching for food at night and in the muddy waters that many of the fish inhabit.

Catfishes in general are omnivorous, feeding on animal life, and are not averse to downright scavenging. They are very hardy, and few other fishes can live longer out of water. Since they have dangerous spines on dorsal and pectoral fins, fishermen soon learn to handle them circumspectly. A small variety of catfish, known as mad toms, have the pectoral fin spine hypodermic needlelike and connected with a poison gland. When jabbed into a person's finger or hand, the fin causes a hurt that feels like a severe bee sting, causing intense pain for an hour or so. No permanent harm results as in the case of a poisonous snake bite, for the fish poison is not very toxic.

The name channel catfish is a term rather loosely applied by fishermen to several of the larger fishes of large streams.

Fully a dozen of our numerous kinds of catfishes are important as food. Their flesh is white, flaky, of a delicate texture and fine flavor. It is preferred to trout by many persons.

Horned Pout or Bullhead

(*Ameiurus nebulosus*)

Usual Length, 10 Inches

One of the best known catfishes is the common bullhead of ponds, lakes, and streams of the eastern and middle States. It is distributed westward from the Dakotas to Texas. It has been introduced on the West Coast, too, where it is well known. Another fish of this round-tailed genus is the black bullhead (*Ameiurus melas*) which has much the same distribution.

The horned pout prefers shallow, warm, weedy, and muddy lakes and ponds, with or without much vegetation.

Bullheads are easily raised in ponds, and under proper management yield a good supply of white and palatable fish food. They are caught on worms, meat scraps, bits of fish, and crayfish by still fishing. Small traps and nets are used by the commercial fishermen.

The bullhead eats during the day but mostly at night, prowling along the bottom with barbels widely spread. It will suddenly pause, then sink headforemost into the mud for some unseen prey. It is not particular what it eats, bolting almost anything convenient, but it prefers insect larvae, pupae and nymphs, crustaceans, bivalve mollusks, and snails.

Catfishes make their nests usually in sheltered spots, such as can be found under rocks, submerged logs and stumps, and old tiles. Apparently both male and female do considerable excavating, and finally make a saucer-like hole. Both fins and mouth are used to clear the bottom so that the gravel is exposed.



Painting by Hashime Murayama

SCALELESS SKINS, SMALL EYES, AND LONG FEELERS IDENTIFY THE CATFISHES

Largest is the **Blue Catfish** (lower two). At top right is the **Channel, or Spotted, Catfish**. Familiar in most States is the hardy **Horned Pout or Bullhead** (at left, middle and top).

After the nest is complete, the spawners pass much time lying side by side with their tails to the opening of the nest. This quietude is interrupted by circular swimming movements, increasing in frequency as spawning time approaches.

Both fish remain at the nest and help incubate the eggs, the male doing most of the guarding. The eggs are fanned constantly until the young hatch, when paddling stops, and the parents swim over the young. These tiny young catfishes become coal black in a few days, at the end of which time they rise in a cloud off the bottom and begin swimming away from the nest.

Four basic methods of reproduction are employed in the families of catfishes, but in America we have only two. *Ameiurus nebulosus* incubates its eggs in a nest, but the male of the marine catfish, *Felichthys felis*, incubates the eggs of this species in its mouth. The eggs of such marine catfishes are large and few in number as compared with those eggs incubated in nests.

The eggs are held loosely in the mouth of *Felichthys felis*, between the bronchial arches and the floor of the mouth. The latter is so much lowered that it gives the catfish the appearance of a double chin. A large male, twenty-two inches long, may have 55 eggs in its mouth. These eggs measure between three-fourths inch and one inch in diameter. During the incubation period, which takes about two months, the male catfish does not feed at all. Its stomach is shriveled and lacks all trace of food. The young catfish or eggs in the mouth of the male are never swallowed unless by accident when the fish are caught in nets.

Fresh-water Drum

(*Aplodinotus grunniens*)

Usual Length, 20 Inches

The fresh-water drum, or sheepshead, as it is known in the northern part of its range, belongs to the croaker family, Sciaenidae, members of which usually live along the shores of all warm seas. None occur in deep water, and a few species are confined to fresh water. Many of the croakers reach a large size and are of much commercial importance as food.

The fresh-water drum is generally distributed throughout the Great Lakes region and Mississippi Valley, preferring large rivers and avoiding small streams. It is a remarkable species, interesting because of its food and feeding structures, and its ability to produce a peculiar grunting sound.

The sheepshead reaches a length of three or four feet and a weight of 40 to 60 pounds. It is a food fish, wherever taken, and is more popular in the South than in the North. It becomes tough and strong with age, but is best when weighing less than three pounds.

The drum is a bottom fish, living mostly in

muddy waters, feeding on snails, mussels, and crayfish, which it is well equipped to crush. In its throat, or pharynx, are located the "pharyngeal jaws," bones which have heavy paved or millstonelike teeth, controlled by powerful muscles. It does not feed upon other fishes, the half-grown and young ingesting aquatic insects, such as may-fly larvae.

Its relation to the pearl mussel that it devours is not altogether one-sided, for it thus exposes itself to infection with glochidia, or the larval stage of the mussel, so that of all fishes it commonly carries the heaviest load of young mussels to be fostered, transported, and planted on the river bed. (These grow up to become the food of other drumfish.) According to Dr. Coker, it is the only known fish that systematically, if unintentionally, aids in the growth of its own food.

Not all of the mussels it carries are directly valuable to man, but at least one useful species, the butterfly mussel, appears to owe its continued existence to the drum; another, the washboard mussel, is aided by it. The drum, then, is to be accounted a resource of double value, first, as an abundant food fish and, second, as an agent in the natural propagation of commercial fresh-water mussels, from which are made so staple an article as pearl buttons.

It is not a popular angler's fish, but is sometimes caught with hook and line baited with crayfish. The young are fair pan fish. The net fisheries take the bulk of those marketed. In the North it is often called sheepshead, while in Louisiana it is best known as gaspergou.

Virtually nothing is known of its breeding habits, although females with ripe eggs have been found in May and June.

The fresh-water drum makes drumming or grunting sounds not unlike those made by the sea drum, and this is the meaning of its specific name, *grunniens*.

The noises made by drums, croakers, and other sound-producing fishes are accomplished in several different ways, but the purring or drumming produced by drums is the result of muscles attached or drawn over the air bladder. The rapid contraction and expansion of the muscles, about 24 times a second, causes the walls of the air bladder to vibrate and to act as a sort of a resonator, intensifying the sound. Since fishes lack real vocal organs, the noises cannot be produced in the same manner as in birds and mammals.

The ivorylike ear bones, or otoliths, of this fish are popularly known as "lucky stones," a fancy originating in a marking resembling the letter L. Otoliths, like the scales, increase in size in proportion to the growth of the fish and on them is left a record of each season's growth. Thus, scientists studying the otoliths can read the age and rate of growth of the fish from which they were taken.



Hashime/Murayama

Painting by Hashime Murayama

THE FRESH-WATER DRUM IS A "NURSERY" FOR ITS OWN FOOD AND FOR BUTTON "PEARL"

Larval-stage mussels "infect" the **Fresh-water Drum** and are later dropped on the river bed. The adult mussels become a favorite food of the drum and some species provide commercial mother-of-pearl. A large fish of the Great Lakes and the Mississippi Valley, the drum is of considerable value as a market species, but of little interest to anglers except in the South. It has heavy crushing teeth, and feeds chiefly on mollusks and crayfish

Small-mouth Bass

(*Micropterus dolomieu*)

Usual Length, 12 Inches

Until 1927 only two species of black basses were known; then Dr. Carl L. Hubbs, of the University of Michigan, turned up the third species. It is remarkable that a third species of black bass could have occurred in North America for so long a time before its presence was discovered, since all three were the subject of enthusiastic angling.

Before this new one, now known as the spotted bass, *Micropterus pseudaplites*, was recognized, specimens of it were usually classified with the large-mouth bass, mostly because of color similarities. Structurally it is nearest the small-mouth bass, *Micropterus dolomieu*. (This latter species was originally distributed from "Quebec to northern Minnesota and south to eastern Oklahoma and the Tennessee River drainage" but has been introduced in western North America and elsewhere.) All of the black basses belong to the sunfish family, Centrarchidae.

The spotted bass occurs from "southern Ohio and West Virginia to southern Illinois, southeastern Kansas, eastern and southern Oklahoma, and east central Texas; east to Alabama, western Georgia and the Tennessee River drainage of Virginia." These two species may be distinguished since the color pattern of the small-mouth bass consists of vertical dark bars, less distinct and obscure with age, the caudal spot faint or absent, while in the spotted bass the color pattern consists mostly of a lateral series of dark blotches more or less forming an irregular longitudinal stripe, the caudal spot prominent. A dark streak along each ventral lateral scale row in adults, absent on small-mouth bass, helps give it its name, spotted bass.

The favorite habitats of the small-mouth bass are cool flowing streams and large clear lakes. The adults often lie in the protective backwater pools behind a large boulder, stump, or rock ledge of a stream.

The small-mouth black bass reaches a maximum length of a little more than two feet and a weight of about 12 pounds, though one weighing four pounds is a good prize. This is a much larger size than the spotted bass, which attains a length not more than a foot and a half and a weight of about 2½ pounds.

Small-mouth bass build nests from April to June, when the temperature becomes suitable at 59° to 65° F., on beds of gravel rubble, bedrock or coarse sand, usually in three to six feet of water. The male constructs the redd, or nest, by vigorously cleaning the debris from the bottom with its fins and mouth. The male induces the female to come over the nest, and spawning occurs, the eggs being deposited in the bottom of the nest on the

stones. During a week of incubation the male guards the nest and fans the eggs with his fins. He continues watch over the young and protects them for some time after they are hatched. The adults are mature at four to six years and may live until they reach 14 years or older.

Large-mouth Bass

(*Huro salmoides*)

Usual Length, 14 Inches

The large-mouth black bass, distinguishable from the other two black basses by its large mouth, has the upper jaw extending considerably beyond the eye instead of just below its rear margin. The color consists chiefly of a more or less regular longitudinal dark stripe and a small but distinct caudal spot. Originally it occurred throughout the Mississippi Valley, Great Lakes region, Gulf Coast streams, Florida to North Carolina, but now has been extensively introduced in most sections of the United States. Thus its northern range overlaps the southern range of the small-mouth bass, and practically all of the range of the spotted bass.

The large-mouth bass is a fish of warmer waters than the small-mouth bass and is most abundant in weedy, mud-bottomed lakes and ponds, sluggish streams, backwaters, and swamps. Among the black basses it reaches the largest size and in Florida specimens weighing about 24 or 25 pounds, and more than three feet long, are occasionally taken. The usual weight is two or three pounds. The size of the bass depends largely on the waters it inhabits and those reaching the extremely large sizes occur in waters abundantly supplied with food organisms. Food for the young consists of insect life and water fleas, and the adults feed mostly on fish.

The expert angler thinks he can distinguish the species he has hooked before seeing it, since the small-mouth bass is by far the gamier and more active. Its reputation as a game fish is not surpassed by any other of its size.

Although the black basses are cultivated and distributed both by governmental agencies and by private effort, they are not fishes whose mature eggs can be stripped by hand and developed in hatchery buildings by wholesale methods. The propagation is effected by the more natural but slower method of pond culture, in which the fishes are provided with the conditions most favorable to their mating and the rearing of their young.

Angling for black bass indicates that both large and small-mouth species readily take spinners, plugs, live minnows and worms offered by casting, trolling, or still fishing. As a popular game fish it may safely be placed next to the small-mouth bass.



Painting by Hashime Murayama

HOW THE LIGHT-TACKLE ANGLER THRILLS TO THE SMASHING STRIKE OF A SCRAPPY BLACK BASS!

The **Small-mouth** (lower right and jumping) originally ranged from Oklahoma and the Tennessee River drainage to southern Canada, but has been introduced extensively throughout the United States. The **Large-mouth Black Bass** (left) overlaps the habitat of the former and continues to Florida and the Gulf Coast region. In the gamier small-mouth the upper jaw does not extend beyond the eye as in the latter species.

Black Crappie or Calico Bass

(*Pomoxis sparoides*)

Usual Length, 8 Inches

The black crappie belongs to the sunfish family, Centrarchidae, and occurs endemically east of the Rocky Mountains, in southern Canada and the United States, in both lakes and streams. It is especially abundant in the Mississippi Valley and the Great Lakes region. Since it is a good food fish and well adapted to cultivation in ponds, its distribution has been considerably extended to include the Pacific Coast States as well.

The black crappie has a close relative, the white crappie (*Pomoxis annularis*). The two species are not always recognized by anglers, and both may occur in the same waters. The black crappie has a relatively deeper body and is darker in color. Naturalists easily distinguish them by their dorsal spines, the black crappie having seven or eight and the white crappie five or six. The dark markings on the side of the former do not have the tendency to form vertical bars or rings as they do on the white crappie.

The calico bass is chiefly a feeder among aquatic vegetation where it procures aquatic insects and their larvae, as well as small forage fishes such as minnows. It is most active during the early morning and evening and at night. When kept in ponds it lives peaceably with other fishes. It is cultivated extensively in pond fishculture probably because it is able to thrive in shallow, dirty or silty water, subject to wide variations in temperature.

The usual length of the black crappie is about eight inches, though they sometimes reach a length of a foot or a little longer. Although they seldom exceed a pound and a quarter in weight, examples weighing 2 pounds have been reported. Their flesh is firm, delicate and of a fine flavor. It is one of the better pan fishes.

So many black crappies are taken by anglers that this species along with the white crappie has been called "the fish for the millions." It is highly valued for food, especially as a pan-fish when taken from clear water. Crappies are caught commercially, the catch not exceeding 500,000 pounds for the entire United States for both species.

The most successful bait used in fishing for black crappies seems to be live minnows and worms. Fly fishing is gaining in favor. The black crappie will take spinners and insects too, though less frequently.

From May to early July, the black crappie selects gravel as a place to excavate a circular nest on the bottom in shallow water or in water five or six feet deep, often among aquatic vegetation or near it. These nests are about a foot in diameter and spawning takes place in them when the water temperature reaches about 64 to 68 degrees Fahrenheit. The eggs

adhere to the stones, to fine gravel or sand on the bottom, or to the roots of aquatic plants in the nest bottom. The male guards the nest and eggs until the fry become too active for him to manage. The young appear to select some cover, but the species is not notably a shelter-loving type.

White Crappie

(*Pomoxis annularis*)

Usual Length, 8 Inches

The white crappie, *Pomoxis annularis*, family Centrarchidae, occupies the same area as the black crappie, namely the region east of the Rocky Mountains and from southern Canada to the Gulf states. It is abundant in lakes, ponds, bayous, and small rivers and creeks, where the waters are sluggish. It prefers warm muddy bottom, lakes, and rivers. In the Mississippi Valley where the river overflows into ponds and bayous, the young literally swarm, and vast numbers perish each year when these waters dry up.

A fish of so wide a range naturally has many local names. Around the Great Lakes it is called ringed crappie, pale crappie, and strawberry bass. In Louisiana, the name sac-a-lait is most commonly used but it is well known elsewhere under no fewer than twenty-two other local names.

This crappie is strictly carnivorous, feeding on aquatic insects, larvae, crustaceans, and fishes.

The best method of taking white crappie is with live minnows, although a one-half- to six-eighths-inch gold-plated spinner with a piece of fish flesh attached to the hook serves very well. If a bamboo fly rod is used, the angler will get all the action desired.

Mr. Gowanloch says "In using this flesh lure on the bare hook, backed up with the gold-plated spinner, you simply let it down in the water, let the boat drift with the wind, guiding it so that it will keep a path in the general direction you wish to fish. Put no split shot or sinkers on the line. Work the lure with twitches of the rod occasionally to turn the spinner. Sooner or later you will obtain a strike, and a catch is made. It is then possible to anchor at the spot for, where one crappie is to be found, there you will likewise find others, generally a school of them."

The white crappie spawns during May and July in water three to six feet or deeper, commonly under submerged brush or against a stump, and has practically the same habits as the black crappie. The male jealously guards the eggs and nest and keeps the water about them in constant motion with his pectoral fins. Other fish are kept away and if they come too close are savagely bitten.

It grows to a weight of nearly three pounds but the usual size is less than a pound. Its flesh is delicious and is a fine pan fish.



Painting by Hashime Murayama

PAN FISH DE LUXE, CRAPPIES HAVE BEEN CALLED "THE FISH FOR THE MILLIONS."

Throughout the United States and southern Canada east of the Rockies, anglers take them in great numbers. The **Black Crappie** or **Calico Bass** (lower) is especially abundant in the Mississippi Valley and the Great Lakes region. Both this species and the **White Crappie** (upper) feed on aquatic insects and their larvae, crustaceans, and small fishes. Both are food species of commercial value and also good sport fish, taking worms, flies, or spinners



© Roland W. Reed

OJIBWAY INDIANS OF NORTHERN MINNESOTA ARE ADEPTS WITH THE FISH SPEAR

Some of the northern tribes of Indians still use this type of "fishing rod."



Photograph by Doris Day

"BOY! IT'S A WHOPPER!"

Barefoot boy, willow pole, canine pal, and fighting fish—an unbeatable combination!



Painting by Hashime Murayama

THE PARENTAL DUTIES FALL TO THE MALE ROCK BASS

He excavates the nest and guards the eggs until they hatch. As soon as her eggs are deposited, the female "leaves home" and does not return. The **Rock Bass** is common in streams and lakes throughout the Mississippi Valley, Great Lakes, and eastern and southern United States. It is a delicious food fish and is taken in great numbers by amateur fishermen. A pair of fair-sized rock bass will fill the frying pan. It is also called "red eye" and "goggle eye."

Rock Bass

(*Ambloplites rupestris*)

Usual Length, 10 Inches

The rock bass, red eye, or goggle eye, is one of our commonest game fishes in streams and lakes throughout the Mississippi Valley, Great Lakes, and eastern and southern United States. Probably through fish cultural operations it was introduced into the States east of the Alleghenies, but in the Roanoke River of Virginia there is a native species named years ago, *Ambloplites cavifrons*. *Ambloplites rupestris* has been introduced extensively into Pacific Coast States. It is a member of the sunfish family, Centrarchidae, to which belong the black basses.

Percy Viosca, Jr. in 1936 described as new a rock bass, *Ambloplites ariommus*, from Louisiana and Mississippi. In life the general ground color of this rock bass is olivaceous above, blending into straw or oyster white below; these lighter markings are overlaid with and often obscured by black shadowy cloudings, spots and dots. Above the lateral line all scales show metallic green reflections. On the sides the color is olive green, and here the reflections vary between greenish gold and old gold, with a pearly iridescence of a bluish or pinkish cast.

Below the dorsal fin is a wide vertical bar of dark blotches. A black spot is discernible on each of the body scales and this marking often gives the appearance of continuous longitudinal stripes rather than rows of squarish spots as in the common northern rock bass.

A. rupestris and *A. ariommus* may be separated by the dark bars on the median fins. The former has six on the dorsal and anal fins, eight on the caudal fin instead of four and six, respectively, on the new form.

This new rock bass is secretive, hiding deep in the shadows, and the large eye might indicate nocturnal feeding habits, Mr. Viosca believes. That it is seldom taken and practically unknown to anglers can be attributed only in part to the fact that Louisiana anglers fish in large streams or in bodies of water where the species is not found. Its game fish associates are well known, and take the artificial fly readily. It is more than six inches in length and can be classed as a first quality food fish, since its flesh is firm, flaky and of delicate texture and fine flavor.

The better known rock bass, *Ambloplites rupestris*, of more northern States, is taken in large numbers by amateur fishers wherever it abounds and during the greater part of the year. The trolling spoon and other artificial lures are used successfully. However, the rock bass has few of the fighting qualities of the black basses.

The methods of the expert angler are not at all necessary for the capture of the red eye, for it takes worms, crayfish, meat scraps, va-

rious insects, and minnows. Often it is caught at night, a fact that shows its tendency for nocturnal feeding when most sunfishes are quiescent. The rock bass is a thick-bodied, meaty fish, and a couple of fair sized ones will fill the pan. There are specimens in aquaria and museums more than a foot long, and the species is known to grow somewhat larger.

In its feeding habits the rock bass is about as omnivorous as any other member of the bass-sunfish family, to which it belongs. Crayfishes and other fresh-water crustaceans, aquatic insects and their larvae, snails, and such fishes as its rather large mouth will admit, all contribute to its natural food supply. If we include the grasshoppers, crickets, grubs, earthworms, and other terrestrial baits used in catching it, the food list might be considerably extended. Fish culturists have found that this species not infrequently cannibalizes to some extent on its own young.

At spawning time, late in May, the rock bass makes its nest in shallow water along shore, like basses and sunfishes generally. The fishes are sociable at this time and their nests are often found in groups close together, which is not the habit with the pugnacious male black basses.

The rock bass, like other Centrarchids, excavates a nest on the bottom of a lake or stream, usually on gravel or stones, and protected by the male fish. The male works energetically, fanning out the sediment with his fins, thus making a basin-like depression, eight or ten inches in diameter, and cleaned of all debris. The female is driven into the nest and is carefully guarded until the eggs are laid. During the process of spawning the two fish lie side by side in the nest, the female reclines on her side and a few eggs at a time are extruded through the red bluntish ovipositor of the female, being fertilized the same instant by the male. After all her eggs are deposited the female leaves the nest and does not return.

The eggs are carefully looked after by the male, which takes up a position over the nest, and every little while sets up a fanning motion with his fins. During the breeding time of the rock bass the colors are greatly intensified, especially the dark-edged ventral fins of the male and the white edged ventrals of the female. In a few days after the eggs are hatched, the fry gradually rise out of the nest and become so adventurous that they are abandoned by the male.

The tiny young rock bass, shifting for themselves, seek weedy places where they can find shelter and ample food for their growth. If weeds are not available, young rock bass occur around rocks and stones, darting in among them at the slightest disturbance. Among the weeds and stones they feed on small aquatic insects, water fleas, and other tiny organisms that are available. As they get older they take larger animals, including small crayfish.



Hashime Murayama

Painting by Hashime Murayama

MANY GOURMETS VOTE THE WHITEFISH THE TASTIEST OF ALL OUR FRESH-WATER FISHES

Abounding in the Great Lakes and other large lakes of the northern United States and Canada, the **Whitefish** is the basis of an important fishery. In 1937, the combined catch from both Canadian and United States waters was about six and a half million pounds. Depletion continues, but fortunately the species responds readily to artificial propagation. Several hatcheries along the Great Lakes are devoted to its increase.

Whitefish

(*Coregonus clupeiformis*)

Usual Length, 18 Inches

The whitefish along with its close relatives, the ciscoes, or lake herring, belong to the whitefish family, *Coregonidae*. This family, not far removed from the salmon family, is found throughout the Northern Hemisphere, in Eurasia and North America. Whitefishes, with few exceptions, are lake fishes, though some species live most of their lives in streams. The whitefishes are usually referred to three genera: *Coregonus*, lake whitefishes; *Leucichthys*, ciscoes or lake herring; and *Prosopium*, the round whitefishes.

One of the most abundant and important food fishes of the North is the common whitefish, which inhabits the Great Lakes and some other large lakes of the United States and Canada.

There are several species of the genus, mostly of restricted range, inhabiting lakes in the Northwest as far as Alaska, but the common whitefish is abundant in the Great Lakes, far exceeding the others in commercial value.

The common whitefish is in the main the species on which the "whitefish" industry is based. The catch in 1919 exceeded 6,000,000 pounds, or about half the quantity taken in 1890, but in 1936 only a little more than four million pounds were taken, so heavy is the drain made upon this food resource. The whitefish catch along the Canadian shores of the Great Lakes being equal to that of the United States, we may double the above figures.

The common whitefish fortunately responds readily to artificial methods of propagation, and several hatcheries along the Great Lakes are devoted to its increase. The spawntaker grasps the female firmly in both hands, the left at the tail and the right near the pectoral fins. With the head of the fish against his body the female's body forms a modified crescent. Gentle pressure by the right hand as it is moved toward the vent causes the eggs to flow freely into the pan. The milt is obtained in the same manner. Eggs and milt are mixed, stirred, water is added, stirred again. After a few minutes the water is poured off and they are washed. The eggs are placed in a keg, transported to the hatchery, incubated and hatched in glass jars.

It is doubtless the favorite foodfish derived from inland waters. Planked whitefish is considered as great a delicacy in the Lake regions as planked shad around the shores of the Chesapeake.

The largest part of the catch is made in Lake Michigan and the least part in Lake Ontario. The gill net is the principal apparatus used in capture, but many fish are taken in pound nets and seines. The whitefish is

seldom taken with the hook, and then only with worm or insect bait.

It inhabits chiefly the deeper parts of the lakes, moving into shallower waters early in summer, in midsummer seeking again the cooler depths. In the fall months whitefish again come inshore to spawn, some of them entering streams for that purpose, but the migratory movements vary somewhat in the different lakes.

In the Bay of Quinte, Ontario, Dr. J. L. Hart observed that the spawning migration of adult whitefish occurred during October. Fishermen take whitefish in greatly increased quantities at the time of the spawning run. The males, which have definite breeding colors and nuptial tubercles or pearl organs, usually arrive first on the spawning grounds, a reef covered with from one to six or seven feet of water. The bottom is composed of flat stones and a few "hard heads" overlaid with a thin layer of fine silt. During spawning there is considerable jumping and playing of the fish in the shallow water, and this occurs mostly at night.

The average sized common whitefish lays between 8 and 15 thousand eggs. Spawning takes place during late October, November, and December, and the eggs are found between the stones and in the crevices. They hatch by the next April.

The whitefish larvae, after hatching, come to the surface over the spawning grounds, where they remain for a few days and then make their way to the shore where they concentrate in water of about one foot depth. When they reach a length of more than an inch, they seek the bottom in deeper water. Young whitefish an inch or two long eat small crustaceans.

Recent investigations have shown that the common whitefish is late in maturing, probably not spawning until after five years of age. It deposits on the average about 35,000 eggs, which hatch in about five months.

The food of the whitefish consists of small crustaceans, small mollusks, and insect larvae, but chiefly of various kinds of Entomostraca.

Whitefish hatched in the New York Aquarium were carried through the critical period of infancy on a diet consisting of the larvae of mosquitoes. These fishes lived and grew for ten years on a diet of chopped fresh meat. These specimens were apparently the only whitefishes ever brought to maturity in captivity.

Whitefish eggs and young whitefish are devoured in great numbers by predatory fishes. The largest whitefishes seldom reach a weight of 20 pounds, and such are rare, the average as brought to market being only three or four pounds. Females are larger than males.

The whitefishes as a group are considered the most important fresh-water fishes in the world, and there can be no doubt that they are undergoing progressive depletion.



Hashime Murayama

Painting by Hashime Murayama

THE GIANT OF THE TROUTS IS A FISH OF THE DEEP, NORTHERN LAKES

Ranking next to the whitefish in commercial importance, the **Lake Trout** has been known to reach a weight of 100 pounds. Market fish today average about ten pounds. The annual net catch by United States fishermen in the Great Lakes is almost ten million pounds. Popular as a sport fish, the lake trout is usually taken by trolling. This species is called "Mackinaw trout" in the Great Lakes region, "togue" in Maine, and in Canada "namaycush."

Lake Trout

(*Cristivomer namaycush*)

Usual Length, 24 Inches

The lake trout or Mackinaw trout, family Salmonidae, of the Great Lakes belongs chiefly to the fish trade, but throughout its range in most of the large lakes of British Columbia, Alaska, northern United States, and northward beyond the Arctic Circle it is a game fish of importance. In the Great Lakes the angler's share is small in comparison with the commercial catch.

It is the largest of all trouts and is known to have reached a weight of 100 pounds. The average of those taken commercially at the present time is less than 10 pounds, while those caught by anglers along the shore average but half that weight. Many years ago in northern Alaska specimens of this trout exceeding three and a half feet in length were taken in a large lake at the headwaters of the Kowak River, above the Arctic Circle, where they were very abundant.

The lake trout is easily distinguished from other trouts by the numerous small, pale-yellowish spots which cover its body from head to tail, and the complete absence of such red spots on the side as are found on brook trout.

Those from deep water of Lake Superior are called siscowet, and several years ago were taken in great numbers, gill nets being set at times in depths exceeding 500 feet and lifted by steam power.

In the lakes of Maine it is called togue, while in Canadian lakes it goes by the Indian name of namaycush.

Lake trout occur only in the larger deep lakes. They are essentially fish-eaters, and seldom grow to a large size on other than a fish diet. Doctor Forbes tells of a 20-pound lake trout that had 13 good-sized lake herring in its stomach. Thus an abundant population of forage fishes, such as smelt, ciscoes, or alewives is needed. The presence of weed beds is not essential for the production of lake trout. They are voracious fish.

While on a cruise north of Apostle Island, Dr. Townsend observed a steam fishing boat operating 40 nets, each 600 feet long. These were set in one "gang," constituting a single net more than four miles in length. Each deep-water fishing boat attends to four or five of these great nets. As the net was lifted by the windlass forward, it was carried aft in sections, put together again, and paid out over the stern. The nets were about eight feet wide, with four-and-a-half-inch mesh. The largest of the deep-water trout taken by the vessel was two feet ten inches long and weighed 21 pounds.

Some time later, Doctor Townsend passed a day on a steam fishing boat in Georgian Bay near its connection with Lake Huron, and the lifting of a gill net six miles in length was

observed. It was set at a depth of 100 feet and the work of lifting and resetting occupied five hours. The catch was nearly 1,000 pounds of lake trout, the largest of which was three feet long and weighed 15 pounds.

There are many vessels in the Great Lakes engaged in such wholesale fishing, as long as the lakes are free from ice. The annual net catch of lake trout in the Great Lakes is around 10,000,000 pounds.

Lake trout are taken in Georgian Bay at depths of about 50 feet with hand line and trolling spoon, but the sport would be better if rod and reel were used. Anglers who have used the rod with 300 feet of line and minnows for bait find that the fish can be played in a satisfactory manner.

Surface trolling, when the trout are found in shallower waters, affords wonderful sport. In smaller and shallower lakes, like those in Maine, where summer temperatures are higher than in the Great Lakes, the lake trout is often taken with the fly. In Seneca Lake, in New York State, it is taken with a special trolling rig, designed to play the spoon 10 or 20 feet under the surface.

In Squam Lake, New Hampshire, Dr. Daniel Merriman observed the breeding activities of lake trout in shallow water on rocky reefs in October. At this time they leave the deep water, where they have passed much of the summer, and come up on the reefs to clear the rocks and stones of all debris, algal growths, and slime in preparation for the laying of eggs. They work over the bottom, mostly at night, slowly and carefully, until it becomes clean, sharply contrasting with the surrounding areas.

After the bottom has been cleaned to their satisfaction, they spawn, and the eggs settle down among the crevices and stones to develop. Once deposited the eggs receive no protection from the adults, which leave the spawning grounds.

Lake trout are caught during the winter through the ice in some sections by a method known as "bobbin'." A hole must be cut in the ice, fairly small at the top and shelving outward through one or two feet of ice so that in pulling up a trout there is little chance of knocking him off against the edge of the hole. A strong hook, attached to a line with a sinker, should be baited with small pieces of minnow or sucker.

The line is not held still, but a definite bobbing motion makes the bait look lifelike a short distance off the bottom. Often a lake trout will come in and nose your bait but not take it, and then suddenly one will coast into sight and snap up your lure. You must strike hard and quickly, pulling the fish to the surface as fast as possible so that he does not get any slack line. Once thru the hole in the ice, the prize is worth all the long, cold wait that has been endured during its capture.



Painting by Hashime Murayama

WIDELY INTRODUCED IN THE EAST, THE FIGHTING RAINBOW TROUT HAS WON NEW FOLLOWERS BY THE THOUSANDS

Capable of enduring warmer water than the brook trout, the **Rainbow Trout** of the Pacific slope has supplanted the native fish in many streams no longer suitable for that species. No other trout can surpass the superb battle offered by a rainbow hooked on light tackle in a cold mountain torrent. A new movement for stream and lake improvement promises greatly to assist the increase of all our trouts. (See also the Plate on page 273.)

Rainbow Trout

(*Salmo gairdnerii*)

Usual Length, 12 Inches

The rainbow trout belongs to the Pacific slope of the United States in the streams that flow down off the Rockies, the Sierras, and the Cascade and Coastal mountain ranges from Alaska to California. Wherever it is found to the eastward of these ranges, it has been introduced by fish cultural activities. With its broad, iridescent, purplish-red band along the side, the rainbow trout is well named.

There are several geographic races of this trout, and the form now found in the streams of the mid-western and eastern states is without doubt a blend of these several races, brought about by hybridization in fish cultural activities. Rainbow trout eggs from California, Oregon, and Washington have been so extensively shipped eastward that the original rainbow from the Mount Shasta region of California can no longer be distinguished from those of Oregon and Washington.

Commencing in the early eighties, the original stock of a form known as *Salmo gairdnerii shasta* was widely distributed from the government hatchery on McCloud River south of Mount Shasta. It was the good fortune of Doctor Townsend to be attached to this station to participate in that work.

Additional forms of the rainbow have received names. In British Columbia, Kamloops Lake and the adjoining region is occupied by *Salmo gairdnerii kamloops*, while the form that migrates freely to the sea, known as the steelhead is usually called by the scientific name, *Salmo gairdnerii gairdnerii*. The name *gairdnerii*, being older, replaces the name *irideus* so often used in connection with rainbow trout.

The introduction of the rainbow trout in eastern States provided a substitute for the brook trout in many waters which as a result of advancing civilization had become unsuitable for that species.

While generally not as large in the East as in its native western lakes and streams, it has, in certain favorable localities, been found even larger. It can endure warmer water than the brook trout and live farther downstream than that species. Somewhat warmer waters are tolerated by the rainbows than by the other species of trout, but no lake is likely to become populated with any species of trout unless a large part of its volume is cold water and well oxygenated throughout the year. In the Great Lakes region, where rainbows have been introduced extensively, they are the most migratory of the trout, and drop downstream into the large lakes, where they live and grow rapidly, returning where possible to the stream for spawning. These rainbows, then, have adopted the migratory habits of the steelhead of the Pacific coastal streams.

While the rainbow trout is a springtime spawner on the Pacific slope, depositing its eggs from January to May, it has adapted itself in its eastern habitat to the very different climatic conditions prevailing there and now spawns anytime from early winter to spring.

The vitality of the artificially fertilized eggs has made it possible to ship them to great distances in a half-incubated condition, after which the hatching process can be completed by ordinary fish-hatchery methods. In this way fertilized eggs of the rainbow trout have been sent to the Atlantic coast, to Europe, and even to New Zealand in refrigerated packages with little loss. This is the method now used in distributing not only trout and salmon, but many other kinds of fishes.

The acclimatization of this fish in other parts of the United States and in foreign countries is one of the notable successes of modern fish culture. Taken to New Zealand in the late eighties, it soon became well established there, along with Pacific salmon.

Eastern anglers do not usually rate the rainbow with the brook trout as a game fish, but we cannot believe that this criticism applies in its native rivers. It is, perhaps, true that the brook trout is a better food fish. Anglers have their own ideas on such matters, and are not to be dissuaded from opinions formed in places where they have enjoyed good sport.

In the streams of the West Coast and in Glacier National Park we have taken three and four pound specimens, but the average is smaller. It is known to attain a weight of 10 pounds, especially when transplanted to warmer waters, or where the food supply and the large area of a lake provide conditions favoring greater growth.

It is probably not so gamy a fish in warm waters as in mountain streams. We have seen it leap repeatedly when hooked, a thing the brook trout or black-spotted cutthroat trouts seldom do when taken in mountain streams. To me it is one of the most superb game fishes, its sudden vicious striking of the bait or lure with a rush, followed by persistent leaps, twists, dodging here and there, make it a most sought-for prize.

With ever increasing fishing, the continual restocking of trout streams has become more and more necessary and important, but the supply of trout has not been materially increased even with the great efforts put forth by fish culturists. Thus there arose the necessity for *stream and lake improvement*, which during the last few years has swept over this country like an uncontrolled forest fire. Stream improvement consists of improving the environment, increasing production of fish foods, and increase of the spawning areas. This is accomplished by constructing obstructions or partial dams and current deflectors; the building of covers or hiding places for trout, and reforestation to stop dangerous erosion.



Photograph by Leonard Seiling

TO SNATCH A FLY, A HUNGRY BRONZEBACK BRAVES THE UNNATURAL ELEMENT

For a brief moment, a black bass flies through the air. This amazing photograph of a favorite game fish of American lakes and streams was taken with a speed camera—with the help of infinite patience and good eyesight.



Photograph by E. R. Santen

BROOK TROUT, BEST BELOVED BY MULTITUDES OF LIGHT-ROD FLY-FISHERMEN

Also known as "speckled trout" and "squaretail," it thrives in cold torrents which grosser fishes do not enter. The brook trout, native to the eastern and northern parts of our country, has been transplanted with great success to many sections of the Far West. No part of our outdoor heritage is more worthy of conservation than the rapid trout waters of the mountains.



Photograph by Mills and Bell

WITH THE CONFIDENT SMILE OF VICTORY, W. C. VOGT LANDS A 32-POUND "MUSKIE" ON FEATHERWEIGHT TACKLE

Its fins erect, and its mouth snapped shut, the gamy fighter hasn't yet given up the struggle. No ordinary angler would be as sure of himself as this sportsman who boats the prize with his left hand in its gill. A bass fly, single hook, and spinner were used. The scene: a rocky gorge in the St. Croix River, Wisconsin.



Photograph by E. K. Santos

THE CALICO BASS DERIVES ITS NAME FROM ITS MARKINGS

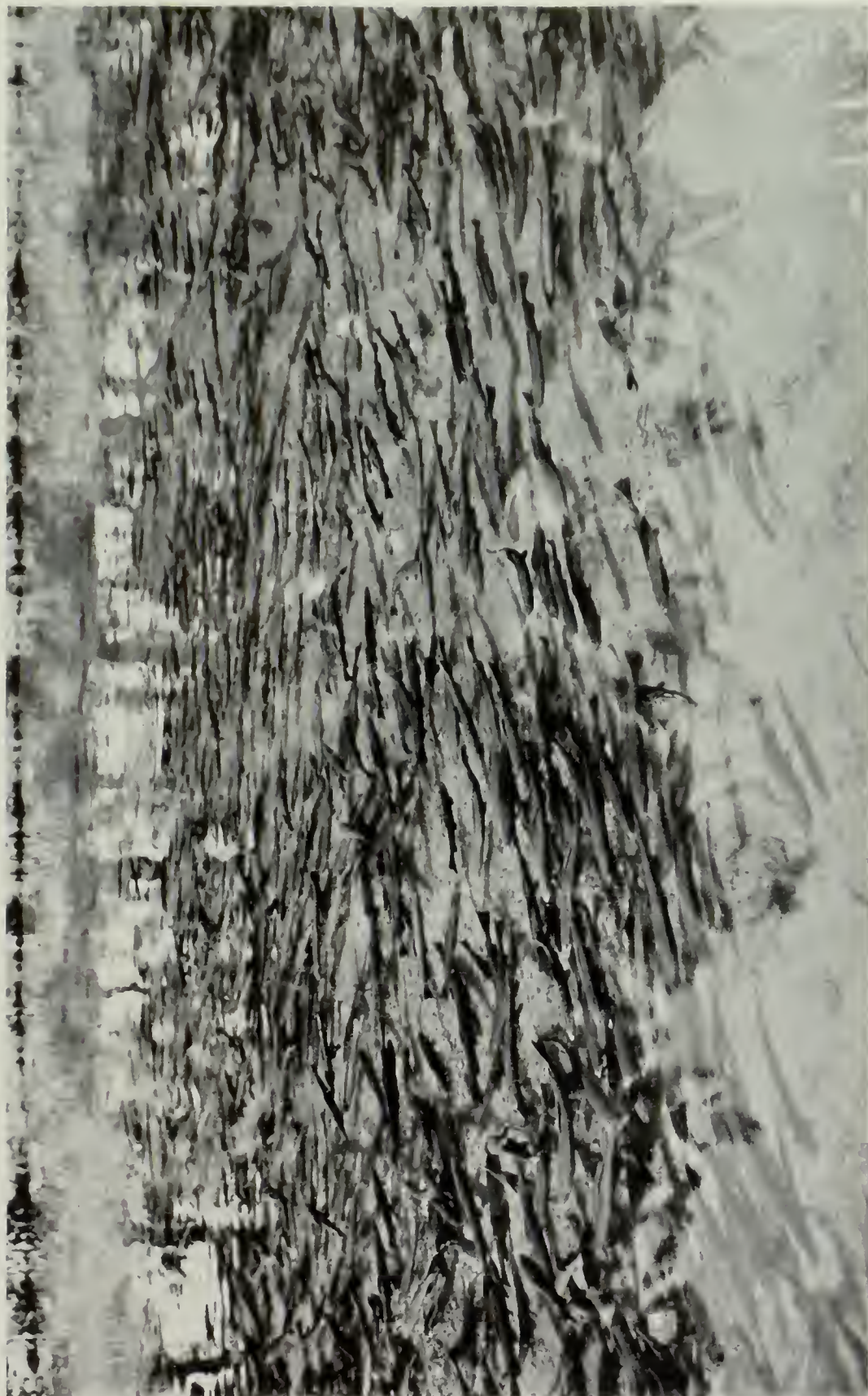
This fish is neither large nor noted for gameness, but it is the object of a vast amount of angling over a considerable part of the country. Market fishers make big catches in the Mississippi Valley. It is highly valued for food, especially as a pan fish when taken in clear water.



Photograph by Scenic America Company

AN ANGLER MEASURES HIS CATCH FROM CRATER LAKE, FORMED WHEN A HUGE MOUNTAIN BLEW OFF ITS HEAD

There were no fishes in this clear, deep-blue body of water until rainbow trout were introduced by the Government. Crater Lake, Oregon, is six miles long, four miles wide, and in one place 2,000 feet deep. Its surface is 6,000 feet above sea level, its steep walls rise from 500 to 2,000 feet above its surface, and it has no apparent inlet nor outlet.



Photograph by Clifton Adams

PART OF 2,200 ADULT RAINBOW TROUT IN ONE POOL AT WARREN, NEW HAMPSHIRE

The State operates five fish hatcheries and one rearing station, where brook, rainbow, and golden trout and salmon are raised. Eggs are procured from wild fish of the lakes, breeding fish kept in ponds at the hatcheries, or from eggs obtained from commercial hatcheries or in exchange with other States. The hatcheries have a capacity of 12,000,000 fish fry.

Brook Trout

(*Salvelinus fontinalis*)

Usual Length, 10 Inches

The brook trout is one of the favorite game fishes of America. Originally found from Labrador westward to the Saskatchewan and southward along the Alleghenies to Georgia, it has been carried by fish-culturists to the Rockies, the Sierras, the West Coast States, the upper Mississippi Valley, and wherever else rapid streams or lakes of suitable temperature are found.

It has almost disappeared from lowland streams in the North, which have become unsuited to it as a result of deforestation and water pollution. In its place, the rainbow trout, a fine sportsman's fish, has been introduced. It takes the fly much like the brook trout and is not a competitor of it for the rainbow occupies warmer water and a habitat closer to the mouths of streams.

The brook trout persists in small coastal streams where the conditions favorable to it have not been disturbed, and it often descends to brackish water. It will live in streams having a summer temperature as high as 70 degrees, provided they have swift currents.

The brook trout cannot live through the summer in the New York Aquarium without the aid of refrigerated water, although the city supply is derived in part from the Catskill Mountains and flows 100 miles underground. The brook trout will live in cool lakes and ponds, but cannot reproduce in such situations without access to the gravelly beds of spring fed brooks at spawning time.

Brook trout culture in America dates from the early fifties. Fish culturists raise great numbers of brook trout, both for market and for distribution in small artificial ponds, by feeding the fishes and caring for the eggs in hatchery troughs provided with flowing spring water.

The instinct to move upstream is very strong in young trout; when a miniature "fish-way" with its stairs of tiny box pools is connected with a hatching trough, they will promptly begin to ascend and cannot, in fact, be kept down while water is allowed to flow through it.

In lakes where there is an abundant food supply, the brook trout was once known to reach the rare weight of 10 pounds; but today, when thousands of anglers are whipping the trout streams, a one-pound trout is a large one. The brook trout is not a leaping fish, like the bass or rainbow trout, when hooked, although it may rise clear of the surface in striking the fly. No native game fish is more worthy of protection in the waters suited to it than the brook trout. Many good trout waters have been ruined by the ill-advised introduction of predatory fishes.

Brook trout, when planted in high moun-

tain lakes with adequate spawning grounds in which there are no predatory fishes, soon become very abundant. An example is Lake Ellen Wilson of Glacier National Park where they average about a pound.

The coloration of the brook trout is extremely variable. In some waters the fish may exhibit all the brilliancy of which it is capable, while in another watershed not far away it is so dark that but little color is discernible. A notable illustration of this is found on Long Island, the trout on the south side of the island being among the showiest of the species, while those of the north side are as dark as the brook trout ever becomes. Nevertheless the supply on both sides is maintained by hatchery-raised fishes. After a few months in captivity, the bright colors of the former tend to disappear, while the latter become somewhat paler. This may be due largely to a change in diet and the exclusion of direct sunlight from the tanks.

In the trout, as in many other fishes, the colors vary with age.

In streams the brook trout is largely a feeder on aquatic insects, while in lakes and ponds it feeds much on small fishes. In an aquarium it subsists cheerfully on chopped fish, like the other captives of the tank, and in the average hatchery pond becomes a fat, liver-fed gourmand.

Near Ithaca, New York, Dr. A. S. Hazzard observed the breeding activities of brook trout, and he states that the male and female begin to ascend to the spring-fed headwaters of streams late in September and congregate in the deeper pools below the spawning beds late in October. Preparation of the nests is at its height about October 20, the peak of spawning occurring during the first week in November, when the water temperature is 49 degrees F.

Brook trout always spawn over gravel which may vary in size from sand to stones, three to four inches in diameter. The nest is a round or oval depression from one to two feet in diameter and from two to ten inches in depth. The size and depth appear to vary directly with the size of the female and the swiftness of the current. The nest is usually located at the foot of a pool just where the water breaks, but some nests occur in the riffles, too. All nests observed by Doctor Hazzard were either immediately below springs or in places where seepage entered through the gravel.

The female prepares the nest by darting upstream into the gravel, turning quickly upon her side and undulating her body vigorously against the bottom with a sweeping action of the tail. This action continues for a day or two and a male is always in attendance whenever the female is at work on her nest. The male takes no part in nest building but constantly fights off intruding males.



Painting by Hashime Murayama

ONE OF THE "ROYAL FAMILY" OF FRESH-WATER FISHES IS THE SPORTY BROOK TROUT

Found originally from Labrador to Saskatchewan and southward, in the Appalachian Mountains, to Georgia, the brightly-clad **Brook Trout** has been successfully transplanted to many areas in the Rockies and the Far West. Deforestation and water pollution have restricted its natural range, but artificial propagation maintains the stocks in many heavily-fished regions. It is not only a fine fighter on the fly rod, but also a delicacy on the table.

After a few hours to a day or so of courtship activities by the male, spawning occurs when the male approaches the female and forces her partly upon her side. Both fish vibrate vigorously, and eggs and milt are extruded at the same instant. After spawning, the female covers the eggs by working a little upstream from them, the sand and gravel loosened by the sweeping movements of her tail being carried downstream over the eggs.

The average nest contains about 200 eggs, and hatching usually does not occur until the next spring. In the natural reproduction of brook trout, about 70 per cent of the eggs hatch. The fry, as soon as the yolk sac is absorbed, make their way up through the gravel of the nest into the stream and soon begin feeding. At the end of the first year the young may grow to a length of two or three inches, the size depending on the abundance of food organisms available to them.

White Perch

(*Morone americana*)

Usual Length, 7 Inches

The white perch, *Morone americana*, belongs to the family Moronidae, in which is classed the rock or striped bass, *Roccus saxatilis*, a food fish, now of great economic importance on the Atlantic and Pacific coasts.

The white perch belongs to the tidal region of the Atlantic coast from Nova Scotia to South Carolina. It is abundant around Long Island and in the Hudson River up as far as Albany. It is taken through the ice in the Hudson, where it is present throughout the year.

It is equally abundant in the Delaware and Susquehanna rivers and Chesapeake Bay, ranging well upstream, and is commonly taken in pound and fyke nets along the coast.

It is commonest in brackish water, and the largest numbers are taken in the lower sections of tributary streams. Good catches are also made in the spring during the spawning season, far up rivers where the water is always fresh. It is taken chiefly in the spring and fall, from March to May and September to November.

Along the Atlantic coast between one and two million pounds of white perch are caught annually by commercial fishermen. Anglers catch it in abundance and consider it a good food fish even though its maximum weight does not exceed three pounds. The average weight is a little less than a pound. White perch sometimes reach a length of 15 inches.

The white perch is good eating, either from fresh or salt water. Hook-and-line fishermen find shrimp bait the best, but the fish responds readily to minnows, young eels, small crabs, or any of its natural foods. Specimens of two or three pounds are reported from the eastern end of Long Island. In fresh waters,

worms, grasshoppers, and other insects are effectively used.

The white perch rises to the fly, especially in fresh waters, and resists bravely when hooked. A fish a foot long weighs about 2 pounds, but this is larger than the average.

It is a gregarious species, usually frequenting the shallower waters alongshore.

Considering the adaptability of the white perch to the conditions of captivity, especially in brackish water, there is reason to suppose that it will receive more attention from fish culturists than it has in the past. Anglers would know it better if its range extended farther inland.

There are few native fishes that live equally well in fresh or salt waters. The white perch, living chiefly in brackish tidal water, ranges freely into both. In rivers it passes up beyond all trace of salinity and often becomes landlocked in strictly fresh ponds, where it breeds for considerable periods. On the other hand, it is taken in abundance about coastal islands where conditions are altogether those of the salt sea.

In aquaria it has been kept for long periods, either fresh or salt, but the best results have been obtained in tanks supplied with both kinds of water. There are ten-year-old specimens now living in such artificially maintained brackish water. They have reached lengths of 10 to 12 inches and continue to be hardy under the restrictions and the monotonous fare of life in captivity.

Years ago specimens of live white perch intended for exhibition were obtained from one of the park lakes in New York City where they had been introduced; but, although fully protected, the supply gradually diminished to the vanishing point. It seems, therefore, that the race cannot breed indefinitely in fresh waters, but must renew its fertility through occasional baths in the vitalizing sea.

Complete exclusion from the brackish or fresh waters, where it spawns, would doubtless lead to extermination as readily as long-continued imprisonment in absolutely fresh water. According to the records of anglers, the largest specimens are those taken in salt or brackish waters.

The white perch normally spawns from April to June, although evidence has been found that it may spawn in December in Chesapeake Bay. Usually the spawning is at its height about the last of April or early May. The spawning fish are about four to seven inches long. The eggs are laid in fresh or slightly brackish water and stick together in masses or to any object on which they chance to rest. In fact, they are so sticky that it is difficult for fish culturists without much experience to handle them. The eggs are small and hatch in six days at a water temperature of 51 to 53 degrees Fahrenheit.



Hashime Murayama

Painting by Hashime Murayama

THE LIVELY AND ABUNDANT WHITE PERCH IS EQUALLY AT HOME IN FRESH AND SALT WATER

One of the few fishes which flourish in both coastal and inland waters, the **White Perch** is found in greatest numbers in the tidal region of the Atlantic Coast from Nova Scotia to South Carolina. Large quantities are taken in nets. It ranges far up the rivers, and inhabits many lakes, where it has apparently become land-locked. Averaging about a pound in weight, the white perch will take an artificial fly and give a brisk fight.

Yellow Perch

(*Perca flavescens*)

Usual Length, 10 Inches

The yellow perch belongs to the perch family, Percidae, with numerous representatives in Europe and east of the Rocky mountains in America. The European "yellow perch," *Perca fluviatilis*, closely resembles the American yellow perch, and for a long time they were thought to be the same species. Other members of the perch family are the pike-perches and the darters, beautifully colored little bottom-dwelling fishes, in streams and along the shores of lakes.

The yellow perch is one of our best-known fresh-water fishes, being abundant throughout the Northern and Eastern States from Nova Scotia and Quebec westward to Minnesota. On the Atlantic slope it occurs as far south as North Carolina, which is somewhat farther south than it is found in the Mississippi Valley, where it is confined to states bordering on the Great Lakes. It is essentially a lake fish, but occurs also in streams, most abundant in the larger rivers, and least so in creeks.

It has been extensively introduced west of the Rocky Mountains in the West Coast States, much to the regret of sportsmen who are enthusiastic about salmon and trout fishing. Lake Washington, in Seattle, once a wonderful trout lake has become so overpopulated with yellow perch that trout no longer have much chance. The whitefish, *Prosopium williamsoni*, once abundant in that lake has completely disappeared. Perhaps if commercial fishing for yellow perch was encouraged in Lake Washington, the trout would increase in numbers.

In eastern United States and Canada, where this perch does not compete with trout, it is a highly valuable food and game fish.

The market catch from the Great Lakes sometimes exceeds nine million pounds a year, while anglers in towns along the Lakes take great numbers and find sport in so doing. The catch by anglers in smaller lakes and ponds everywhere is very large. Commercially it is taken in gill nets, fyke nets, and traps, or with seines.

The yellow perch comes as near to being everybody's fish as any other and little art is necessary in taking it. It is ready to sample all the baits of the amateur and even responds to baits let down through the ice in winter, when many other fishes are sluggish. The expert takes it both with fly and trolling spoon.

As a food fish, there is none of better flavor among the commoner kinds, for its flesh is white, firm and of an excellent flavor. It is identified by its broad cross-bands of black; no other native fresh-water fish wears the same combination of black and gold.

Like other fishes of extended range, it has several names in different localities, such as

ringed perch, raccoon perch, red perch, or striped perch. Its length may be as much as 14 inches and its weight about three pounds, but such sizes are unusual.

The spawning season of yellow perch is March, April, and May. They come in shallow water along shore; usually the males precede the females, the latter probably remaining only long enough to deposit their eggs while some of the males may linger throughout the spawning season. Usually while the fish are on the actual spawning grounds, the stomachs are empty. The eggs are extruded in zigzag-shaped bands, which, by the rapid absorption of water, become large masses seen along the shores in shallow water. In the northern part of the range, the egg masses may be found at any time after the ice disappears.

Dr. Pearse found a string of perch eggs that contained 2650. Forbes and Richardson mention a string that measured 88 inches and weighed 41 ounces after the excess water had drained from it.

When the strings leave the body of the female they are not larger than a pencil, but they absorb water and swell rapidly. The perch usually string them over stones, plants, or submerged limbs of trees. Hatching occurs in a week or two. The small fry are free swimming, living in schools near the surface, and as they get older they seek protection among weeds and brush close to shore in shallow water.

Yellow perch have been kept eleven years in captivity on no other food than fish purchased in the markets, although their natural live foods include practically all the smaller forms of fresh-water life. The perch is a versatile feeder, taking crustaceans, aquatic insect larvae, worms, small clams and snails, and anything else that is convenient, including the eggs of ciscoes, whitefishes, and other fishes.

In small lakes of an area of three or four acres, Dr. R. W. Eschmeyer has shown that yellow perch will dominate the lake and form what he calls a perch cycle. He found that more than three fourths of the fish were two years old and that there was a great scarcity of one year olds and those that should have just recently hatched.

No doubt the great paucity of available food caused the two-year old fish to subsist on their own eggs or young when these were available. Most of these two-year olds would probably have died of starvation in the following year, although enough adult fish would have survived to assure adequate reproduction. With most of the predators removed by starvation, a large crop of young perch would again result, and these fish all of one age would predominate for two or three years, again keeping down those to be born years following. In such lakes the yellow perch seldom reach legal size to be taken.



Hashime Murayama

Painting by Hashime Murayama

ONE OF THE BEST-KNOWN CITIZENS OF OUR FRESH WATERS WEARS A HANDSOME SUIT OF BLACK AND GOLD

Found throughout the Northern and Eastern States, from Nova Scotia and Quebec to Minnesota and southward to North Carolina, the **Yellow Perch** is essentially a lake fish, although it also occurs in suitable streams. A good game fish, it is a highly valuable and finely flavored commercial species as well. The 1937 catch from the Great Lakes exceeded five million pounds. The yellow perch comes as near to being everybody's fish as any other.

Yellow Pike-Perch, Wall-eyed Pike

(*Stizostedion vitreum*)

Usual Length, 20 Inches

The yellow pike-perch, *Stizostedion vitreum*, and the sauger or sand pike, *Stizostedion canadense*, are close relatives of the yellow perch, and all of them belong to the family Percidae, the true perches. Another species was discovered by Dr. C. L. Hubbs and made known in 1926 under the name of *Stizostedion glaucum*. This latter fish is called the blue pike and occurs in the Great Lakes in abundance, helping make up part of the commercial catch of pike-perches.

Although the wall-eyed pike prefers clear waters everywhere in its range, it is a fish of the lakes rather than the rivers. It is seldom found in lakes or streams with mud bottoms. During the spring and summer it frequents the shallow waters near shore in the Great Lakes but as cold weather comes on it seeks deeper water. It is found from Lake Champlain westward to Minnesota, in the interior lakes of New York, in the Great Lakes basin, and in the Mississippi Valley, but through fish-cultural operations its habitat has been greatly extended. Its range also extends well into Canada.

The yellow pike-perch, perhaps better known as wall-eyed pike, ranks close to the white-fishes and the lake trout in quality and commercial importance among the fishes of the Great Lakes, where the market catch in 1917 amounted to 4,500,000 pounds and in 1936 about 5,000,000 pounds. Its flesh is white, firm, and of a fine flavor. It must be considered one of the most commercially important perches.

Though the average weight of this fish in the Great Lakes is less than 10 pounds, a specimen occasionally reaches a weight of 25 pounds and a length of three feet. In other northern waters the average is less than five pounds. It is a swift and powerful swimmer, capable of overtaking bass and perch.

The yellow pike-perch is essentially a piscivorous fish, but feeds upon crayfishes, too. Minnows, shad, and small sunfishes are common in its stomach. Forbes and Richardson made an estimate of the number of fishes required to feed pike-perch in Peoria Lake, Illinois.

They state: "Reckoning the average life of a pike at three years, the smallest reasonable estimate of food for each pike-perch would fall somewhere between 1,800 and 3,000 fishes, and a hundred pike-perch such as should each year be taken along a few miles of a river like the Illinois would require 180,000 to 300,000 fishes for their food. Probably no other fish in our streams is able to meet so tremendous a demand except the hickory shad—so abundant in the food of this pike."

Perhaps no fish lends itself better to artificial propagation; more than 300,000,000 were liberated from Federal hatcheries on the Great Lakes in 1921 and more than 500,000,000 in 1936. A few millions are hatched annually in the New York Aquarium, where the process of incubation in glass jars always attracts the attention of visitors. As handled in the fish hatcheries, a large specimen may yield 300,000 eggs.

The yellow pike-perch spawns in April. The eggs are small and hatch in two or three weeks after fertilization. Sometimes it runs up rivers to deposit its eggs but also spawns on gravel shoals in lakes and probably on weed beds, too. No definite nests are made and the eggs are scattered over the bottom.

The artificial propagation of wall-eyed pike has its own special technique. George E. Butler describes the process as it is done at the Swan Creek Hatchery on Lake Manitoba, Canada, as follows:

A float 20 by 5 feet and 16 inches high is used to work in and it contains 3 tubs of water, 2 containing the females and one the males. One man scoops the fish from the tubs, handing them to the spawn-taker, and every 10 minutes or so a pan of eggs is ready to be washed. One man does nothing else but wash off the newly fertilized eggs and stir the freshly taken ova.

As soon as the eggs have absorbed water and expanded or water-hardened, they are put into pails and transported to the hatchery, where they are placed in a tub of water, washed off a few times, and then put into the hatchery jars. The entire time elapsed is less than two hours. Once in the jar, the eggs are kept in constant agitation by running water for 24 hours to keep them from sticking to one another and the jar.

Sauger or Sand Pike

(*Stizostedion canadense*)

Usual Length, 20 Inches

The sauger or sand pike belongs to the perch family, Percidae, and is very closely related to the yellow pike-perch. It resembles the latter in general appearance, but in size does not average more than a quarter of its weight. It has fewer rays in the soft dorsal fin than the yellow pike-perch (17 to 19, instead of 19 to 22). It does not have a black blotch at the rear end of the spiny dorsal, as occurs in the yellow pike-perch; and the dorsal has rows of definite spots, while in the close relative the dorsal is marked by reticulations.

The sauger has the same distribution as the wall-eyed pike, that is in the Great Lakes basin and upper Mississippi Valley.

It is a good food and game fish, taken by trolling and casting both with bait and lure. Commercial fishermen take it in nets both in the Great Lakes and the Mississippi River.



Hashime Murayama

Painting by Hashime Murayama

SWIFT-SWIMMING "WALL-EYES" (LOWER TWO) FREQUENT COLD, CLEAR LAKES

An important food and game fish of our North Central States and Canada is the **Yellow Pike-perch** or **Wall-eyed Pike**, the latter being perhaps the more familiar name. Almost five and a half million pounds of this fish were taken from the Great Lakes in 1937. Closely related to the yellow pike-perch is the **Sauger** or **Sand Pike** (top portrait), a much smaller fish with about the same range. Both species are members of the perch family.



A GREAT ATHLETE ADDS TO HIS LAURELS

Gene Tunney lands a four-and-a-half-pound black bass on light tackle under the tutelage of Caruthers Ewing, his guide, philosopher, and friend—and is pretty happy about it! Lake Ontario waters near Cape Vincent, Ontario, yielded up the husky bronzeback.



© Haynes, St. Paul

CATCH YOUR FISH AND COOK 'EM WITHOUT MOVING FROM YOUR TRACKS!

In Yellowstone Lake abounds the Yellowstone trout (*Salmo lewisi*). Close to the shore lies Fishing Cone—one of many hot pools in the region. The surrounding water is very cold.



Photograph by E. R. Sanborn

TEN-YEAR-OLD WHITEFISH DRIFT LAZILY ABOUT THEIR AQUARIUM HOME

These specimens were hatched in the New York Aquarium. Since for some time they were the only whitefishes of known age available, scales from them were used by biologists in cross-checking the results of studies of the ages of wild individuals.



Photograph by F. R. Oakley

PEORIA FISHERMEN EXHIBIT THE GAPING JAWS OF A 26-POUND PADDLEFISH

The grotesque catch from the Illinois River measured four and a half feet. With its odd "bill," the sluggish fish stirs up mud in which are found the minute organisms on which it feeds.



Hashime Murayama

Painting by Hashime Murayama

THESE VORACIOUS RELATIVES ARE RUTHLESS DESTROYERS OF SMALL FISHES

Believed to eat about a fifth of its own weight daily in summer, the **Pike** or **Pickerel** (upper) feasts on many kinds of fishes as well as on water birds and small aquatic mammals. Widely distributed throughout the north, it reaches a weight of 40 pounds or more and is a popular species with anglers, who usually take it by trolling or bait-casting. Similar methods are effective in catching the **Eastern Pickerel** (lower), which lives chiefly east of the Alleghenies.

Eastern Pickerel*(Esox niger)*

Usual Length, 22 Inches

The eastern pickerel belongs chiefly to the region east of the Alleghenies, from Maine to Florida. It reaches a length of two feet and a weight of seven or eight pounds. Two or three pounds would be near the average size, which varies, however, with the locality.

Chain pickerel is a name much used in the North, while Jack is more common in the South. It is often confused with the pike, in waters where both are found.

Like others of the family, Esocidae, it leads a solitary life, except at spawning time. Pickerels captured by bait trolling in New Jersey lakes have been taken in rather shallow places, where they found shelter among water plants. Here also the pickerel deposits its spawn. The eggs are thrown off in long masses like those of perch and are usually seen among submerged brush and weeds. In the North the fish spawns in April and May; in the South it spawns earlier and grows faster.

The pickerel stays in deeper water in winter and is then taken through holes cut in the ice.

In ponds devoted to fish culture a pickerel five years old may be a foot and a half long and weigh two pounds, but rapidity of growth depends upon the abundance of food.

The pickerel will seize a fish half as large as itself and swallow it by degrees.

All fishes of the pickerel family are taken by similar methods. Fishes and frogs are good live baits and are used in trolling, casting, and skittering, and artificial lures are used in the same ways.

"Skittering" is an angler's term; it is done with a long rod and a short line, by jerking the bait along the surface.

The eastern pickerel is a fair game fish, and since it is rather easily caught, both in summer and winter, it soon becomes reduced in numbers in the smaller water areas.

Another species, the banded pickerel (*Esox americanus*), is smaller than the eastern pickerel, and seldom exceeds a foot in length. It inhabits chiefly lowland streams and swamps, often descending streams to brackish water. In the Great Lakes region and in the Mississippi and Ohio Valleys it is called the little pickerel.

The little pickerel was introduced into Crab Creek in the eastern part of the state of Washington. There it does not exceed six inches in length, though it feeds voraciously on trout and other game fishes, yet is of no food value. Probably some one thought they had planted *Esox lucius*, which would have been just as big a mistake.

Many anglers consider pickerel and pike fishing a high form of sport and value the species also as food fishes. We have enjoyed them both on the line and in the pan.

Pike or Pickerel*(Esox lucius)*

Usual Length, 24 Inches

The American pike is probably not distinct from the pike of the Old World, but the latter is believed to be larger. Being more widely distributed and abundant than the muskellunge, it is better known to anglers and is of more economic importance.

The pike, like the others of its family, Esocidae, is one of the notoriously voracious fishes, destroying great numbers of other fishes and many water birds and small aquatic mammals. It is well equipped for predatory life and is believed to eat about a fifth of its own weight daily during the summer months. There is no doubt about its being the enemy of all fishes inhabiting the shallower waters. Only a few pike can find subsistence in ponds and lakes of limited extent.

It is not a suitable fish for propagation in waters adapted to other fishes that are less piscivorous, and its cultivation should be restricted to such localities as are best adapted to it alone, where it may subsist on fishes of the least value as game or food.

The pike reaches a length of four feet and a weight of 40 pounds or more. There are several much-quoted records to the effect that the pike of Europe and Siberia have been known to exceed 100 pounds in weight. Natives of the Alaska Peninsula told Doctor Townsend that pike of enormous size inhabit Lake Iliamna.

It may be that the pike attains its greatest size in far northern waters. In northern Alaska it is found abundant in all parts of the Kowak and its tributaries, especially in quiet lagoons leading off from the river. There are many lurking in shallow water among overflowed mosses and Doctor Townsend, having little time for angling, took such pike as were needed for food by shooting them as they lay in the shallows with hardly enough water to cover them. This was early in August when the cold Arctic streams are about as warm as they ever get, and the pike were probably spawning. In our northern States they spawn soon after the ice leaves, and the eggs hatch in about three weeks.

The annual yield of pike and pickerel in the net fisheries of the Great Lakes exceeds a million pounds. The identity of the pike is often lost in the name pickerel, for the pike is associated with the pickerel in much of its geographic range.

An inhabitant of the shallower waters in summer, the pike in winter seeks greater depths, doubtless following its food supply, and is taken on baited hooks set through the ice. In summer it is a solitary, still hunter, lurking about the edges of weedy or brushy places. It is taken with all sorts of live and artificial baits, in trolling, casting, and skittering.



Hashime Murayama

Painting by Hashime Murayama

TIGER OF THE FRESH WATERS IS THE HUGE AND POWERFUL "MUSKY"

Suggesting the salt water barracuda in appearance and fish-eating habits, the **Muskellunge** is a celebrated game fish, being both big and strong. On light tackle, a large specimen requires the most expert handling to be safely boated. Giant of the pickerel family, the species inhabits lakes and rivers of the northern United States and southern Canada. Forty-pound "muskies" are fairly common.

Muskellunge

(*Esox masquinongy*)

Usual Length, 36 inches

There are so many ways of spelling the Indian name of this fish that we have adopted the one apparently most in use, only after an orthographical search which revealed 24 ways of spelling it. A few of the spellings are: musquellunge, muskallunge, muscallonge, muscullunge. In Canada the fish is called maskinonge. The muskellunge is the largest of the pickerel family, Esocidae, being known to exceed 80 pounds in weight, and 40-pound specimens are fairly common.

It is a northern fish, inhabiting mainly the Great Lakes, Lake Champlain, Lake Chautauqua, lakes of Canada, the St. Lawrence River, and the upper Mississippi and tributaries.

It is celebrated as a game fish, having both size and strength, but in the quality of pure gameness does not rank so high as the small-mouthed black bass or the brook trout. If taken with light tackle, it will be found a foeman worthy of the angler's steel. Chub measuring five to seven inches in length are frequently used as bait. Light tackle requires careful and experienced handling; otherwise considerable difficulty may be experienced in landing a fish.

Immediately when a fish is hooked, it is best to pull for deep water to prevent entanglement in weeds or sunken logs. Near Montreal, from the St. Lawrence River, H. H. MacKay reports the capture of a "maskinonge" weighing 67 pounds and having a girth of 27 inches. Unless equipped with a rod suitable for a large specimen, the angler may have to play the fish an hour or more before landing it.

Live bait casting and spoon trolling are the usual ways of taking the muskellunge.

As a fish-eater the muskellunge rivals the barracuda of salt water, making the same fierce rushes and having a similarly large mouth set with dangerous teeth. There is, in fact, a superficial resemblance between these two widely separated fishes.

With a long, narrow body, strong dorsal and anal fins placed far back on the body, and a powerful tail, the muskellunge is well equipped for speed. It has the look of a three-propeller craft, but its power is reserved for sudden bursts of speed, since it is not given to ranging far from its customary lair. The muskellunge, like other fishes of the pickerel family, is solitary in habit, lurking in sheltered spots from which it darts upon its prey.

As food fishes, neither the muskellunge nor the other pickerels are rated so high as the trouts and basses. The muskellunge has long been on exhibition in aquaria, where 30-pound specimens have lived for four or five years and would have lived longer but for accidents to the water supply. Although well fed, they have occasionally attacked their tank mates.

G. A. Winchester states that the largest specimen taken in Lake Chautauqua weighed 49 pounds. Forty-pounders are taken every season, but seven pounds is about the average for that lake. In Lake Chautauqua was taken a 42-pound specimen which had a length of 52½ inches. In that lake the fish is taken in summer by spoon trolling. In the autumn live baits, suckers, shiners, and creek chubs are used.

Live bait fishing is more effective at night and attracts larger fish. Skittering with dead minnows is fairly successful in summer, and both casting and skittering can be done over weedy places. A good day's catch would be five or six fish. The State hatchery at Lake Chautauqua, between 1896 and 1920, turned out more than 69,000,000 muskellunge fry.

The spawning season begins about April 20 and lasts three weeks. The muskellunge spawns from 100,000 to 300,000 eggs, which are deposited mostly where brush, dead limbs, and logs lie in the water. The tiny fry of the muskellunge feed on animal plankton such as water fleas and other small crustaceans. By the time they reach a length of two inches, they may eat small minnows and in adult life they feed almost exclusively on such fish as suckers, perch, bass, minnows, catfish, and small pickerel.

In Ontario, Robert Peavoy observed muskellunge to spawn in water from six inches to two feet in depth when the water temperature was from 49° to 58° during May.

H. H. MacKay says that when spawning muskellunge swim around in pairs, keeping the same relative position in turning and going under logs, as if they were cemented together side by side. If frightened they separate but soon come together again. They generally remain close to the surface of the water. Their dorsal and caudal fins frequently rise above the surface, and they keep close to submerged dead tree trunks or clumps of grass, rather than go directly across open areas in the water.

The male is more alert than the female but nervous. During the spawning act the fish roll over on their sides, the eggs and milt being extruded and scattered among the vegetation of the waters of the swamp. Hatching occurs in one or two weeks.

The cannibalistic tendencies of the young make the rearing of muskellunge very difficult. Muskellunge do not make nests and protect their eggs and young fry like the black basses.

Unlike bass, muskellunge may be stripped of their eggs and milt in the ordinary way. To do this, the fish culturist places the fish against his left thigh and the head under the left elbow, a gentle pressure is exerted with the right thumb against the ventral surface of the body and the ripe eggs pour out freely from the vent as the thumb is moved toward it. The milt is stripped by a similar process.



Hashime, Murayama

Painting by Hashime Murayama

WITH A "BEARD" OF BARBELS, THE STURGEON FEELS FOR ITS FOOD

As soon as the sensory appendages come in contact with some mollusk, crustacean, worm, or small bit of plant life, the fish thrusts out its tubular, toothless mouth to suck in the food. Largest fish of the Great Lakes is the **Lake Sturgeon**, distinguished, like others of its family, by five longitudinal rows of heavy, bony scales, or bucklers. Until the value of its flesh and roe was realized, the lake sturgeon was destroyed as useless. It is now scarce.

Lake Sturgeon

(*Acipenser rubicundus*)

Usual Length, 40 inches

The lake sturgeon belongs to a remarkable group of fishes, the sturgeon family, Acipenseridae. Sturgeons occur throughout the Northern hemisphere, in North America, and Eurasia. Some species are confined to the lakes and streams, and others are anadromous like the Pacific salmon. In North America there are about seven species, two on the Pacific Coast and the others east of the Rockies.

The sturgeons are fishes of ancient lineage, the species having been more numerous in former ages, when they were more heavily armored with body scales, than are those now existing. All sturgeons are at once distinguishable by their five longitudinal rows of heavy, bony scales or bucklers. The mouth is located on the under side of the snout, in front of which are four fleshy barbels.

The lake sturgeon is the largest fish of the Great Lakes and, next to the paddle-fish and the giant gar of the Mississippi River, the largest fresh water fish east of the Rocky Mountains. It never reaches the great size of the sea sturgeons ascending rivers of the Atlantic and Pacific coasts. Milner, who examined many in the early seventies, saw none longer than six feet, but found reports around the Lakes of larger sturgeons. In 1922, a sturgeon was taken in Lake Huron which measured seven feet, three inches and weighed 225 pounds.

Of course this is small compared with the big sturgeons of the Columbia and Fraser rivers of the Pacific drainage. L. J. Farley, Prosser, Washington, caught near the mouth of the Yakima River an eleven-and-a-half-foot specimen weighing 826 pounds. A. B. Chapman, of Seattle, Washington, took from the Columbia River an eleven-and-a-half-foot female in 1917 near Kalama, Washington. It weighed 835 pounds and contained 90 pounds of eggs.

The largest of all Columbia River sturgeons reported was taken near Vancouver, Washington, by A. B. Chapman in May or June, 1912. It was twelve and a half feet long and weighed 1,285 pounds. From the Fraser River we have record of a ten-and-a-half-foot sturgeon weighing 1,015 pounds. All of these big ones are the white sturgeon (*Acipenser transmontanus*) and they must take record of being the biggest fresh water fish of North America.

The history of the sturgeon is a story of wanton waste. In 1872 Milner reported a fishing firm at Sandusky, Ohio, engaged in preparing smoked sturgeon and caviar and using from 10,000 to 18,000 sturgeons a year. Before this firm began to utilize them, the local catch of sturgeons, which were always present in the nets, had been destroyed as useless.

This was also the practice elsewhere on the Lakes. Around Saginaw Bay they were piled on shore to decay.

When the value of the fish was finally recognized, its decimation proceeded so rapidly that it soon became scarce and has been so ever since.

The difficulties encountered in the propagation of the sturgeon by artificial methods have so far been only partly overcome. The breeding sizes available for experimental fish-culture are now so limited that extermination is feared.

The sensitive snout and the four barbels in front of the mouth are used for locating food on the bottom. The method of feeding, according to Doctor Breder, Jr., is to cruise slowly along, with the barbels dragging or touching the bottom. As soon as these sensory appendages come in contact with some food object, the tubular mouth is shot downward so that it is directly over the morsel by the time it reaches the bottom, the fish usually not checking its pace. In fact, because of the rather inflexible state of the paired fins, it is rather difficult for a sturgeon to stop its forward motion abruptly. This is compensated for by the comparatively great distance between the sensory barbels and the mouth.

The lake sturgeon ascend streams in the spring to spawn, usually in May and June. They also spawn on rocky ledges near shore. The eggs are glutinous and adhere firmly to sticks, rocks, and other objects. Hatching occurs in a week or two.

The young, when two or three inches long, are protected by their spinetipped buckler plates, which are already well developed.

Sturgeons seldom live more than two or three years in aquaria, but doubtless would live longer in captivity were it practicable to keep them in mud-bottom pools and supplied with their natural foods.

In 1880 the catch of sturgeons in the Great Lakes exceeded 7,000,000 pounds. In 1917 it had fallen to less than 100,000, and in 1936 to 25,000. In the upper Mississippi River and its tributaries the catch has fallen in proportion. When we consider that the caviar alone from a single female Atlantic sturgeon is worth nearly \$100, it is easy to realize what the passing of this fish means. Such is the rate at which we are harvesting our wild crops.

The sea sturgeons have also decreased at a rapid rate and fish-culture has made little progress in propagating any of them.

The lake sturgeon is inoffensive so far as other fishes are concerned, except as it may disturb their eggs, being strictly a bottom feeder and living on mollusks, crustaceans, worms, and more or less small plant life. Its mouth, devoid of teeth and placed on the under surface of the head, is sucker-like in form and can be protruded downward like the vacuum-action mouths of suckers.



Painting by Hashime Murayama

MYSTERIOUS AND AMAZING ARE THE SPAWNING MIGRATIONS OF THE FAR-WANDERING EEL. The **Freshwater Eel** reproduces in deep water south and southwest of the Bermuda Islands. Only the females go far up our rivers. The smaller males remain in tidal waters. Both sexes die after breeding once.

Freshwater Eel

(*Anguilla bostonensis*)

Usual Length, 30 Inches

The problem of the breeding places of the common or freshwater eels is one of great antiquity, and only during the present century were any real results attained. It was known for a long time that eels moved down the streams of the Atlantic drainage of the United States and southern Canada, as well as the Mississippi River and other Gulf Coast streams, and if they were not caught by commercial fishermen soon disappeared in the sea never to be seen again.

In Europe the freshwater eel has the same habits and is the object of a great fisheries industry.

In the United States the annual catch of eels for market exceeds one and a half million pounds and is worth more than \$125,000. The catch is made when the eels are working toward saltwater and is heaviest during the dark of the moon. The season is from July to October, inclusive. Large as is the catch of eels in America, that in Europe is vastly greater.

The European freshwater eel (*Anguilla vulgaris*) is a different species from the American eel (*Anguilla bostonensis*) and may be distinguished by the number of vertebrae; the former has 111 to 119 and the latter 104 to 111.

Unlike salmon, shad, and other fishes which enter freshwater to spawn, the eel descends streams at maturity to spawn far out at sea. This type of migration is catadromous in contrast to the anadromous migration of salmon.

The young eels, three inches or so in length, called elvers, enter freshwaters in the spring in large numbers. The baby eels, before they become elvers, only a few inches long, are thin, flattened, transparent creatures, so clear that print can be read through their bodies. When this stage of their life was first described, it was named *Leptocephalus* and was not known to be the larvae of the common eel.

The story that science gives us today about these eels is the result of remarkable discoveries, mostly by the late Dr. J. Schmidt of Copenhagen. When he began his studies he wrote, "We know then that the old eels vanish from our ken into the sea, and that the sea sends us in return innumerable hosts of elvers. But whither have they wandered, these old eels, and whence have the elvers come? And what are the still younger stages like?"

Doctor Schmidt, by carefully collecting eel larvae all over the North Atlantic Ocean and then studying them statistically, found the smallest sizes occurred in a region of the ocean south and southwest of the Bermuda Islands, or approximately equidistant from the Leeward Isles in the West Indies and from Bermuda. Radiating out from this region toward Europe

the eel larvae increased in size until they became elvers off the mouths of the rivers. The smallest American eel larvae were found a few hundred miles to the westward of the breeding place of the European eel. The eggs of these eels have since been found in these localities.

The European eel spawns during the spring and summer. The tiny larvae, about one-third of an inch long, float at a depth of 600 to 900 feet. At the end of their first summer they reach a length of an inch and move up nearer the surface at depths down to 150 feet. Their eastward journey toward the shores of Europe is aided by the eastward movement of the surface ocean waters. In their second summer they are in the central Atlantic and by the end of their third summer have arrived off the coast of Europe at a length of three and one-half inches. In the autumn they change to elvers and soon migrate as eels into freshwater streams.

The American eel on our coast takes only one year to reach the mouths of our coastal streams and soon begins to enter them as elvers at the age of one year instead of three. The adults go far inland, migrating up to the middle Mississippi Valley and in Europe away up to Switzerland.

Females with ripe eggs are unknown, the millions of undeveloped eggs carried by each female not developing while the eels linger in fresh or coastal waters.

The eels found far inland are always females and remain in fresh water for several years. It is only when tending toward reproductive maturity that they seek the sea. Male eels remain in tidal waters and are smaller and less in evidence. Like females, they do not reach breeding maturity until they have passed to sea.

The great bulk of the eel catch everywhere consists of females. It is said that all the eels captured in the great Quebec fishery are females moving downstream.

Enormous numbers of young eels gather below Niagara in spring and summer, but there is no evidence that they ever pass farther by that route. The eels of the upper lakes may pass up by way of the Erie and Welland canals. It may be that limited numbers of eels in the Mississippi River find means of passing into the Great Lakes. It is only the young eels that move upstream. Adults move downstream and do not return. Both males and females die at sea after the first and only breeding season in their lives. The eel is very prolific, each female producing from 5,000,000 to 10,000,000 eggs.

Eels are taken in other ways than with nets. "Bobbing for eels" is done with worms strung on thread. They are also taken in small wire traps called eel-pots, by eel-spears, and even by digging and spearing in the mud, where they bury themselves in winter.



Photograph by E. R. Sanborn

WARM SEA FISHES CONGREGATE AT AN UNDERWATER FIFTH AVENUE AND FORTY-SECOND STREET

At this tank crossroads of fishdom, a moray eel arches above a group including grunts, jacks, spade fish, gray snapper, pork fish, and rock hind. Of the two spotted rock hind (lower right), the left-hand fish displays a habit of the species in resting on its pectoral fins as if on stilts.

SOME CURIOUS INHABITANTS OF THE GULF STREAM

Along Shores Bathed by Tropical Currents Feed Schools of Bright-hued Fishes

By JOHN T. NICHOLS

Curator of Recent Fishes, American Museum of Natural History

WE THINK of tropical seas as the home of a gaudily colored assemblage of fishes. In a sense, this first impression is correct. Active, short-bodied, elastic-scaled, spiny-finned, bright-colored species here occupy the center of the stage.

As a matter of fact, tropical shorelines are the great metropolis of the world's fish life. The evil-visaged, snakelike moray (Color Plate, page 155), one of the most degenerate of true fishes, threads the hidden passages among the coral over which blue angel (Color Plate, page 154) and red, green, or parti-colored parrotfish (Color Plate, page 160) are swimming.

Out on the open sand, spotted flounders lie, matching their background so as to be well-nigh invisible, or little gray gobies move about like shadows, eager to escape detection.

Countless varieties of fishes are hiding in every patch of weed. Schools of silversides, anchovies, and herring dart through the stretches of open water.

It is their function, in the scheme of things, to feed on the minute organisms so abundant in sea water, to multiply prodigiously, and in turn form a basic food supply for a great variety of larger fishes.

To do this and at the same time contribute something to the forces of evolution, however, their numbers must be conserved. Their silvery sides render them difficult of observation by hungry eyes below, and they are available only to the quick and the keen.

ENORMOUS QUANTITY AND DIVERSITY OF LIFE IN THE GULF STREAM

Over the heat equator warm air is constantly rising. Heavier, cooler air from higher latitudes flows steadily in to take its place, and, deflected by the earth's rotation, becomes the easterly trade winds. Before these far-famed winds, millions of waves, reflecting the clear deep blue of the ocean depths under their white crests, go dancing to the westward.

The whole surface of the tropical Atlantic moves, drifting toward the coast of America, is caught and turned about in the Gulf of Mexico, and shoots out past the Keys and the east coast of Florida as the Gulf Stream.

Inasmuch as many young marine fishes and other animals regularly drift in ocean currents, it is easy to understand what an enormous quantity and diversity of life the Gulf Stream must carry.

Furthermore, such waters, when they enter the Gulf, have already flowed under a tropical sun for many, many miles. The Gulf of Mexico is not a place for them to lose calories, and Gulf Stream water has a considerably higher temperature than the 79 degrees found, in general, at the surface of the open ocean on the Equator.

TRULY TROPICAL FISHES IN FLORIDA WATERS

It follows that shores bathed by such water have as truly tropical fishes as if they were situated much farther south.

Essentially the same fishes extend from Florida to Brazil. Scattered representatives of this great tropical fish fauna of the western Atlantic are drifted to the capes of the Carolinas and, to a less extent, in summer, even to New England. We have seen a stray spade fish (*Chaetodipterus faber*) (Color Plate, page 154) on the New Jersey coast and a little butterfly fish (*Chaetodon ocellatus*) (Color Plate, page 155) washed ashore on the south side of Long Island, New York.

It is almost thirty years ago that the writer made a first trip to Florida. After a prolonged period of more or less distasteful, though necessary, indoor activities during a northern winter, he found himself suddenly foot-loose on the Miami water front.

The yachting party that he was to join here on a collecting trip among the Keys was somewhere up the coast, stuck on a sand bank. Meanwhile, there was nothing to do but sit and swing one's heels.

The first objects of interest were the brown pelicans flapping by. Why they did not break their necks on the bottom when they dived precipitately from a height into water not more than two or three inches deep, was something of a problem. If a human diver were to take such a plunge, even phenomenal skill could not save him from disaster.

FISH THAT WEAR VIVID REDS, GREENS,
YELLOW, AND BLUES

But the pelicans were not alone in their ability to see fish. It was soon discovered that a number of interesting species could be observed swimming along the shore. None were more beautiful or so easily identified as the little schools of pork fish (Color Plate, page 153), with their bright yellow markings set off by the bold black pattern on head and shoulders. This fish scarcely belongs with the true, gaudy reef fishes, but rather with those less dependent on the protection of the reef, the golds and blues and rose colors of whose livery are often extremely beautiful, yet seldom striking enough to make the fish conspicuous in the water.

By no means all fishes whose haunts are on and among tropical reefs are brightly colored, but found there are a great number of active species which wear vivid red, green, yellow, blue, orange, etc., and which, furthermore, are marked in the boldest patterns, frequently with black.

Good examples are the rock beauty and the blue angelfish (Color Plate, page 154). Several parrotfishes, butterfly fishes, and others of similarly attractive appearance belong to this class.

Naturalists have offered in explanation that the reef itself was as full of color as a garden of varied flowers, wherein the very brightness of the fishes rendered them inconspicuous. To most observers, however, a coral reef as a whole appears rather monotonous in tone, the many varied fishes swimming about giving it the principal note of high color, and these are not only easily seen but readily identified.

How many northern fishes can one see and recognize as easily, where they are swimming along at considerable depth in the water, as the black and yellow sergeant major (Color Plate, page 160), for instance? Granted that, in general, these colors render the fish conspicuous, can they be classed as warning colors, like the black-and-yellow striping of wasps? Ap-

parently not, for there are plenty of predaceous fish which eat some of them and would doubtless be pleased to consume more.

Immunity colors, they have been called most appropriately. The idea is that a wide-awake, active fish on a coral reef has so many avenues of escape from its enemies, so many projections to dodge behind and holes to hide in, as to be practically immune from attack. It can afford to be as conspicuous as it likes.

Be this as it may, the striking patterns are a great convenience to the ichthyologist, who has to separate one species from another; for nowhere else does one find so many different, but closely related, species living side by side, each doubtless differing from the others in habits in some way, be it ever so slightly.

One of the principal families of fishes in our southern fauna is the sea basses, to which the gigantic jewfish, the rockfishes, groupers, hinds, and so forth, belong. These are all fishes which resemble our northern sea bass. They are big-mouthed and voracious species, living for the most part about rocky or uneven bottom, though also swimming out over open stretches of sand.

A HOOKED BASS SELDOM ESCAPES

Many are food fishes of importance. They have leathery mouths, so that when once hooked they are not easily lost. Though well formed and by no means sluggish, they are solitary and sedentary, as contrasted with the equally abundant predaceous family of snappers, for instance.

Always lurking on the lookout for smaller fishes to come within striking distance, and sometimes associated in considerable numbers at favorable localities, they do not range about, hunting in schools, like the snappers.

The colors of this group are varied and sometimes extremely beautiful, in none more so than in the small rock hind (Color Plate, page 158), whose home is in the bright lights of the coral reef. But the plan of coloring is such as to lower, not raise, the visibility of the fish. Contrast, for instance, the color plans of the rock hind and the bizarre rock beauty.

These groupers, rockfishes, and hinds, furthermore, have the power of undergoing complete color changes almost instantaneously. The color tone becomes lighter or darker and the markings be-



AN OCTOPUS SWEEPS GROTESQUELY ACROSS AN AQUARIUM TANK

Despite its repulsive appearance, the monster is a source of fascination to most people. The head, like a caricature of a sheep, is mounted on a somewhat oval body from which radiate eight arms usually united at the base by a membrane. The arms, or tentacles, are provided with rows of suckers with which it swiftly clasps its prey and clings with surprising strength. The creature has the uncanny faculty of changing color before one's very eyes. All its actions are strangely engrossing to observers. (See Color Plate, page 206.)

come bold or fade and disappear. Such color changes can be seen to advantage in individuals kept in an aquarium. There can be no doubt that in the fish's natural environment it adapts it to the bottom it is swimming over, and, further, that inconspicuousness may aid in its getting a full meal at the expense of its smaller associates.

AN AMATEUR WOULD TAKE ROCK HIND AND SPOTTED HIND FOR TWINS

There is a related fish which has a color pattern almost exactly like that of the rock hind, namely, the spotted hind. The principal technical difference between the two is that one has minute scales on its maxillary and the other has not—a characteristic about as obvious to the layman as what the fish is thinking about. The spotted hind's squarish tail fin, with a broad, blackish border, affords an amateurish, but simpler, way of telling it.

The fish life of warm shores is one of

contrasts. In contrast to the big-mouthed sea basses, there are species, usually sluggish, which have very small mouths, depending for their subsistence on the great abundance of small sea animals found about tropical reefs and ledges, or seaweeds. To capture such small creatures does not require great agility.

The sort of life they lead has probably been taken up gradually, through long periods of time, and many of them have meanwhile acquired remarkable and sometimes quite unfishlike characters of form and structure. None is stranger than the little sea horses (Color Plate, page 156), with body encased in rings of bony mail, horse-shaped head set at right angles, and prehensile tail to grasp the seaweed where they are hiding, body floating upward erect in the water.

The male sea horse carries the eggs in a pouch situated under his tail, until they are hatched and the young large enough to fend for themselves.



Photograph by John Oliver La Gorce

OF THE MANY RAYS, ONE IS A STRIKING BEAUTY

The whip ray, or spotted sting ray, as it is also known, is common in the Gulf Stream areas. This non-edible ray uses its broad, pointed fins much as a bird its wings and seems to fly, rather than swim, through the water. It is handsomely marked with many golden-brown rings.

Sluggish, small-mouthed species frequently have hard nipperlike teeth, as the small animals which they eat are many of them shelly.

Since it is difficult for them to get out of the way of larger predaceous fish, they are variously protected against attack, mostly being colored more or less in resemblance to their surroundings. The trigger-fishes have a stout dorsal spine which locks erect, as well as a very thick leathery hide which must be of some protection. The gaudy colors of the queen trigger-fish (Color Plate, page 157) are an exception among such forms.

A somewhat related flat-sided filefish scarcely swims about at all, but drifts with the tides, more or less head downward,

and can be easily captured in the hand. It is so striped as to be readily overlooked, however, among the eel-grass which is drifting with it.

The swellfishes have the power of suddenly inflating the body with water or air until they assume an approximately globular form several times the normal diameter. Such a performance must be disconcerting to any enemy about to seize one.

The porcupinefish, in addition to doing this, has the body everywhere covered with long, sharp spines which project in every direction like the quills of a hedgehog. Many persons who are familiar with the inflated skins of swellfishes and porcupinefish used by the Japanese as picturesque lanterns will be surprised to learn that both seemingly exotic species are common in local waters.

The trunkfishes, instead of being protected in this way, have the body encased in a bony shell, like a turtle. In the East Indies there are rectangular species,

but ours are all three-cornered, beechnut-shaped. They go by various names—cuckold, shellfish, and so forth, the cowfish (Color Plate, page 157) being a species with two hornlike spines projecting from its forehead. They are excellent eating, cooked in the shell like a lobster.

SOME FISH ARE RISKY DELICACIES

The back muscles of the swellfishes are sometimes eaten, but make a risky delicacy, since there are well authenticated instances of severe poisoning from eating these fishes. The poison seems to be localized in the viscera and to permeate the rest of the fish after death.

In some quarters of Japan swellfish is highly esteemed when prepared for the



Photograph by Luis Marden

A BIG ONE THAT DIDN'T GET AWAY!

Fishermen on the jetty at Laguna Madre, Texas, hooked this jewfish, a member of the sea bass family. The beamy monster is not much of a fighter; yet it makes an exciting catch for novices who like poundage. Outside the barrier islands, in the Gulf of Mexico, tarpon, sailfish, kingfish, mackerel, and jackfish are hooked. In August each year anglers gather from all parts of the United States to take part in the Rio Grande Delta's "fishing rodeo."

table with care, but there is a Japanese proverb to the effect that before eating swellfish one should have one's last will and testament in good order.

Poisoning resultant from eating certain species of tropical fishes is a subject which will repay further study. In Cuba several kinds are reputed dangerous and their sale prohibited in the larger markets. Among them are the great barracuda, green moray and certain species of the carangidæ, or crevally family. On the other hand, this same barracuda is particularly favored as a foodfish in Puerto Rico, as it is known to subsist entirely on clean, live food.

It is said in Cuba that by no means all the fishes of these species are poisonous, and that the smaller ones are safer. The symptoms of poison are sometimes alimentary disorders, sometimes skin troubles. The cause is not known, but Mowbray, writing in the New York Zoölogical Society

Bulletin, presents a strong case in favor of the hypothesis that such tropical fish poisoning is in most cases due to improper marketing. He says: "It is probable that if, when caught, the fish were eviscerated and bled, a case of poisoning would be a rarity."

A bulletin of the Madras (India) Fisheries Bureau thus emphasizes the importance of properly marketing fish in a tropical climate: "Of all general food, fish is most liable to taint and most poisonous when tainted. . . . Fish not kept alive *must be cleaned and washed at sea* and properly stowed. This brings them to shore with a much decreased chance of taint, even if several hours intervene."

THE WARY GRAY SNAPPER

As food fishes, the snappers are perhaps the most important southern family. A snapper is an all-around, up-to-date fish, an evolutionary product of the keenest of

all competition in the fish world, that at the tropical shore-line. It is good to look at and good to eat. Fortunate the diner who sits down to a well-cooked plate of snapper.

There is nothing peculiar or freakish about the snapper. He is just thoroughly successful and modern, active, adaptable, and clever—trim-formed, spiny-finned, keen-eyed, smooth-scaled, and strong-toothed.

Almost anywhere one goes one can see little schools of the gray snapper through the clear tropical water, skirting the shore or the edge of the mangroves, on the lookout for small fry to satisfy their appetites, and at the same time with a weather eye out for possible danger. It would seem a simple matter to catch one on hook and line, but no fish is wariest about being thus ensnared.

Several species of snappers are almost equally abundant, the muttonfish and the red snapper, which is taken in comparatively deep water, being perhaps the most important commercially.

The excellence of the red snapper is widely known, and quantities of this fish are shipped to distant northern markets: For baking, a fine large one has few equals. Bright red color in fishes has often a peculiar significance, which will be spoken of later.

Though not exactly a snapper, the excellent table-fish known as the yellow tail (Color Plate, page 159) belongs to the snapper family. It is somewhat more elongated than the true snappers, with lines more graceful, and its tail-fin is more deeply forked. One sees immediately that it is a freer, swifter swimmer, navigating wider stretches of more open water.

WHY SWIFT-SWIMMING FISH HAVE FORKED TAILS

Most marine animals which swim especially swiftly and continuously have a forked tail-fin. This shape of tail avoids the space immediately behind the axis of the body where the stream-lines following the sides (of a moving fish) converge. A rounded or pointed tail which would occupy such area would be a drag.

Whales and porpoises, though they move the tail up and down instead of from side to side, have a forked tail-fin, only it lies in a horizontal instead of a vertical plane. The wide-ranging members of the mackerel family and other more or less related marine fishes have a forked tail-fin set on

a firm, narrow base; and the freest swimming sharks (mackerel sharks and the man-eater) have acquired a tail of the same shape, though the ordinary shark tail is weak and unsymmetrical.

Fresh-water minnows almost invariably have a forked tail-fin, waters which they have to traverse being considerable in relation to the small size of the fishes themselves.

In the blues and greens of the waters through which it swims, the yellow tail's bright yellow tail probably makes a shining mark, though its colors otherwise are well calculated to give it a low visibility. Are we to conclude from this that there are no larger fishes which prey on it? No; there pretty surely are such fishes, though it may well be so swift as to escape many.

DEEP-SWIMMING FISH ARE OFTEN RED IN COLOR

As regards concealment, having a yellow tail must be a disadvantage to it, and is a characteristic which would doubtless have been lost in the keen competition of the tropical waters where it lives were there not, on the other hand, some compensating advantage. It may be a badge of identification, useful to a school in keeping together.

It has been previously mentioned that the red snapper comes from deeper water than other common snappers. There is a tendency for fishes which swim deep down under the blue or green sea and yet within the range of surface light penetration to be red in color. A great many are not, to be sure, but a larger proportion are red here than elsewhere, frequently a clear bright striking red all over.

It seems almost a pity that the light in which they live is so green that the color, red, must appear an intangible neutral gray! Perhaps it gives them a useful inconspicuousness down there, or perhaps it absorbs a maximum amount of the dim, strongly blue-green sunlight, which is in some way beneficial.

One of the commonest species of the surface reefs, the squirrel fish (Color Plate, page 153), has a regular, bright, "deep-water" red color. But the mystery of how it comes to such a color is easily explained, for it has similar relatives living deeper down. Evidently the squirrel fish has recently come up in the fish world, and its big eyes indicate that it has not yet adjusted itself to the bright light of the surface sun, but is more or less nocturnal.



AMONG THE CORALS ROVES A BRIGHTLY-DRESSED HABITANT

The common **Squirrel Fish** or **Soldato** (*Holocentrus ascensionis*) likes to hide among coral caves and overhanging ledges throughout its range from the Bermuda Islands to Florida and Brazil.



Paintings by Hashime Murayama

A VALUABLE FLORIDA FOOD FISH BEARS TWO SOOTY STRIPES

Abounding in the West Indies and Florida, the **Pork Fish** (*Anisotremus virginicus*) averages about a foot in length. Market fishermen trap it easily.



ANGELFISHES ARE SHOWY BEAUTIES OF THE REEFS

Among the West Indies and the Bermudas lives the **Blue Angelfish** (*Angelichthys isabelita*, lower left). The **Black Angelfish** (*Pomacanthus arcuatus*, upper right), the **French Angelfish** (*Pomacanthus paru*, lower right), and the **Rock Beauty** (*Holacanthus tricolor*, upper left) range from Florida to Brazil.



Hashime Murayama 1912

Paintings by Hashime Murayama

TASTY AS WELL AS HANDSOME IS THE STRIPED SPADE FISH

Also called **White Angel**, the **Spade Fish** (*Chaetodipterus faber*) abounds on our South Atlantic Coast.



QUICKLY THEY DART IN AND OUT AMONG ROCKS AND PLANTS

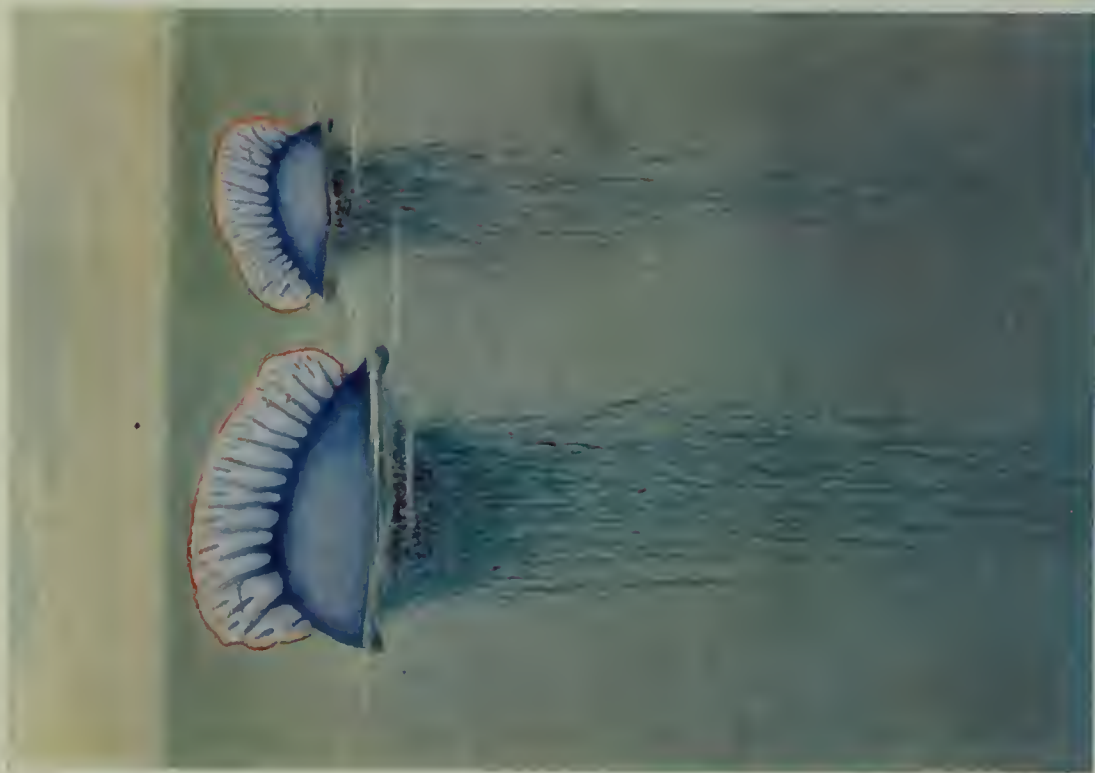
At upper left is the **Four-eyed Fish** (*Chaetodon capistratus*), a parasite hunter that even feeds inside the mouths of larger fishes. The **Butterfly Fish** (*Chaetodon ocellatus*, pair at right) is a conspicuous beauty. Both species stray northward from their West Indian and Caribbean range to Cape Cod.



Paintings by Hashime Murayama

THE LARGEST OF THE EELS GROWS TO A LENGTH OF MORE THAN SIX FEET

The **Green Moray** (*Gymnothorax funebris*) is found from Bermuda and Florida to Brazil.



FORTY-FOOT TENTACLES ENTANGLE TINY VICTIMS

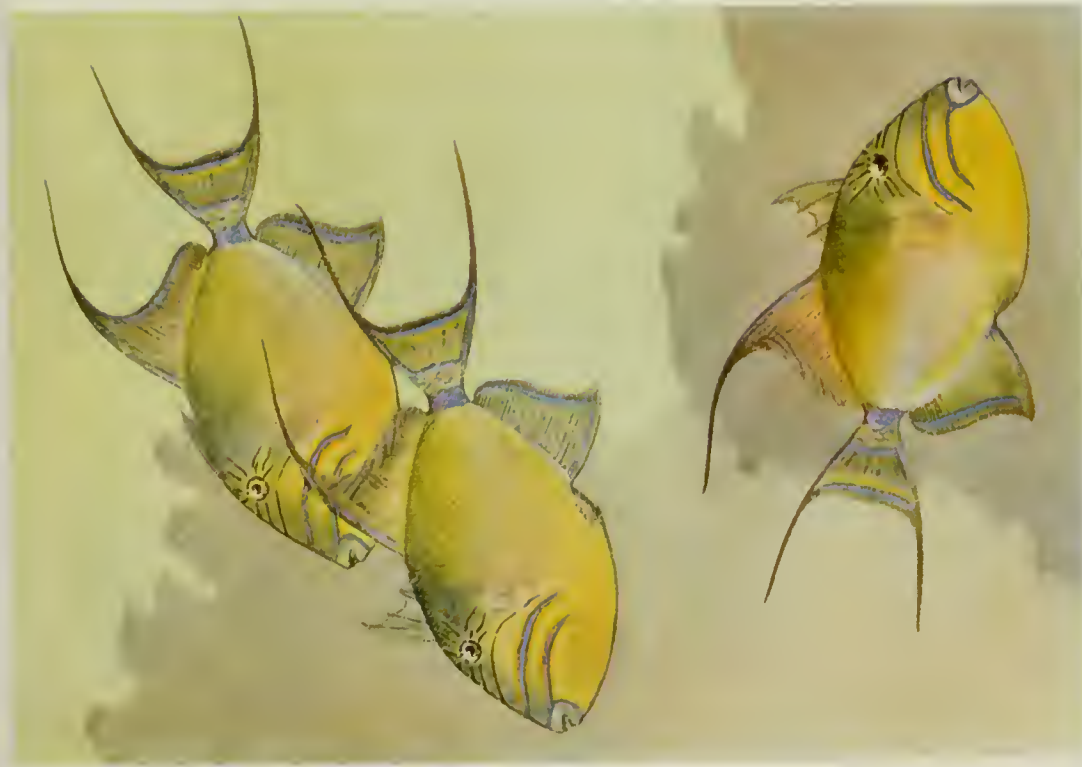
Resembling some strange sea craft, the **Portuguese Man-of-War** (*Physalia physalis*) drifts on the surface with tide and currents, ensnaring small creatures that strike the paralyzing nettle cells of its trailing streamers. It is found in tropical seas, but sometimes strays as far north as Cape Cod (see also Color Plate, page 310).



Paintings by Hashime Murayama

APPLY NAMED IS THE PERKY SEA HORSE

The only fish possessing a prehensile tail is the **Sea Horse** (*Hippocampus*). With its curious appendage, it holds to seaweed while feeding on small crustaceans. The female deposits her eggs in an external abdominal pouch of the male, where they are hatched. Sea horses are found in most warm seas.



THIS "QUICK CHANGE ARTIST" HAS A QUERER FIGURE

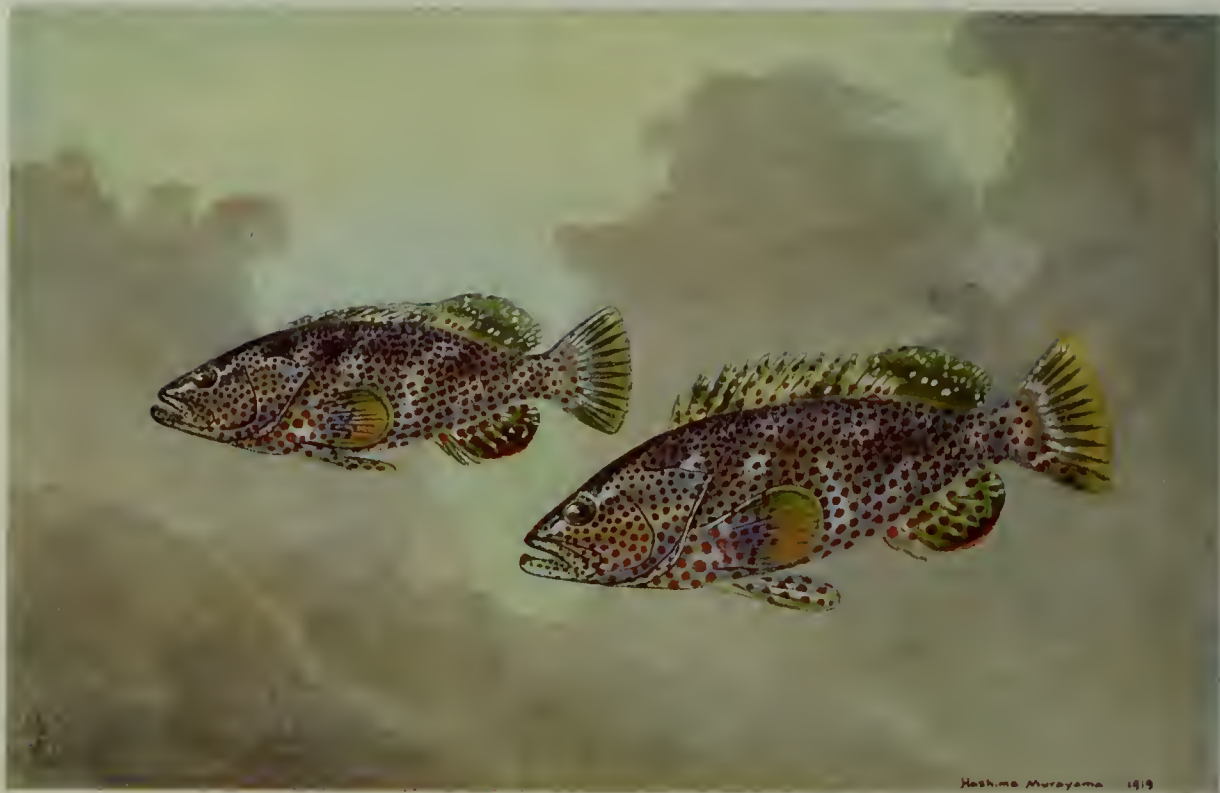
A striking tropical species, found in Florida, the West Indies, the Bahamas, and the Indian Ocean, the **Queen Trigger-fish** (*Balistes vetula*) is capable of extensive and rapid color change. It gets its name from the three-spined first dorsal fin; after the front spine is set upright, it may be released by a touch on the rearmost one.



Paintings by Hashime Miyayama

TRUNKFISHES ARE ODDITIES OF FISHDOM

They are encased in a hard, stiff shell, the fins, eyes, and mouth alone being movable. The **Cuckold** or smooth trunkfish (*Lactophrys triqueter*, top), the **Buffalo Trunkfish** (*Lactophrys triqueter*, lower left, and front view, lower right), and the **Cowfish** (*Lactophrys triicornis*, center) all are food fishes common in Florida waters.



THROUGH WARM SEAS SWIMS A POLKA-DOTTED DANDY

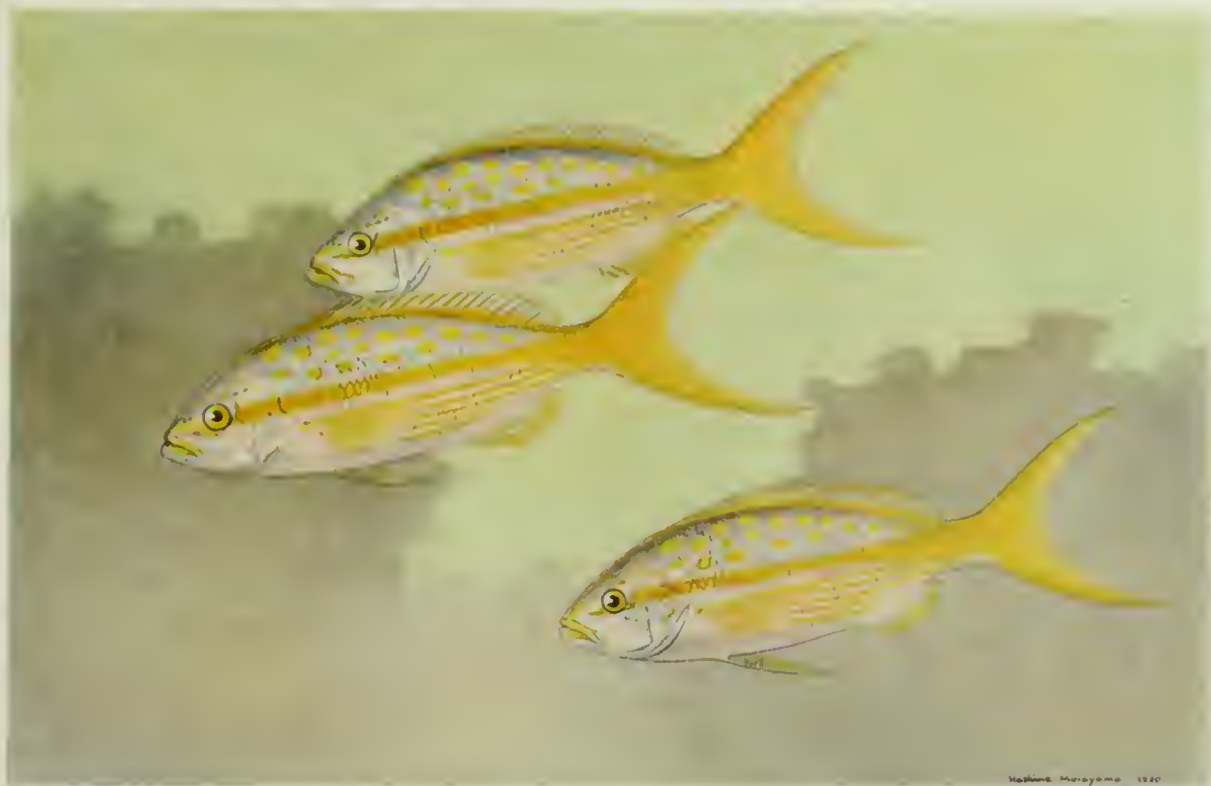
Valued as food, the **Rock Hind** (*Epinephelus adscensionis*) inhabits rocky places in tropical American waters from Bermuda and Florida to Brazil. It reaches a length of about 16 inches.



Paintings by Hashime Murayama

AT STEALING A RIDE, THE SUCKER IS AN EXPERT

By means of a suction disk, the **Shark Sucker** (*Echeneis naucrates*) attaches itself to the larger sharks, to tarpon, and to other big sea creatures. It occurs in all warm seas.



THE YELLOW TAIL IS ONE OF THE GAMEST SNAPPERS

Found in waters off Bermuda, Florida, and the West Indies, and south to Brazil, the **Yellow Tail** (*Ocyurus chrysurus*) is also a favorite food fish.



Paintings by Hashime Murayama

BLUE STRIPES ADORN THIS TROPICAL NATIVE

The **Yellow Grunt** (*Haemulon sciurus*), which feeds on worms and crustaceans, reaches a length of 15 inches. A good food species, it lurks about rocky shores from the Bermudas to Brazil.



VERY ABUNDANT IS THE SMARTLY-BANDED LITTLE SERGEANT MAJOR

Occurring in tropical waters of the Americas in both the Atlantic and Pacific, the reef-loving **Sergeant Major** or **Cow Pilot** (*Abudefduf saxatilis*) is not a food fish.



Paintings by Hashime Murayama

POWERFUL BEAKS SUGGESTED THE NAME OF THE PARROTFISHES

Largest of the tribe is the **Green Parrotfish** (*Pseudoscarus guacamaia*). It averages about 12 to 15 inches in length, but may reach three feet. It can bite through a small fishhook.

The Gulf Stream runs so close to the coast of Florida that, when the wind is right, quantities of the drifting yellow gulf-weed it carries are washed ashore and into the bays. A variety of fishes hide in and about this weed.

One of the commonest and perhaps the most interesting, namely, the mouse fish, spends its entire life in the drifting sargassum. Colored in wonderful mimicry of this habitat, its shape also, grotesquely irregular, covered with leaflike processes or flakes, heightens the resemblance, so as to make it well-nigh invisible. This protection against larger fish which might disturb it probably also serves the purpose of camouflage to enable it to approach and capture smaller fish, crabs, and shrimps.

THE PORTUGUESE MAN-OF-WAR HAS A FAITHFUL COMPANION FISH

The mouse fish, for its size, has a large mouth and appetite in proportion. Many other species hide in the weed when young and, as a rule, have colors to match at that time of life, though later they may be quite different.

The rainbow-tinted pink, blue, or purple bubblelike floats of the Portuguese man-of-war (Color Plate, page 156) drift at the surface over all tropical oceans and are sometimes washed in close to the shore in numbers. With them often comes an interesting companion, a very small and beautifully colored fish called *nomeus*, which never strays far from the tentacles which stream below the man-of-war. When threatened from below, the *nomeus* swims up among those tentacles, safe from its enemies, which respect their powerful sting.

When traveling by steamer along the Florida coast the writer has watched for *nomeus*, and from where he stood on deck has seen one and sometimes more individuals lying suspended in the clear water, their blackish ventral fins conspicuously spread, always within a short distance of a man-of-war, floating above.

Comparatively few kinds of fishes are abundant "off-sounding," away from the influence of the shore-line, and these may be divided rather sharply into the hunters and the hunted. Mouse fish and *nomeus* belong to the latter class—the one hides, the other lives under the protection of a powerful companion.

Flying fishes, which are abundant, have an even more interesting method of escaping their enemies, leaping above the sur-

face and, with favorable wind conditions, shooting through the air for perhaps as much as an eighth of a mile, supported by their long, stiff breast-fins, widely spread at right angles to the body. When there is a whole-sail breeze blowing they seem to fly also for sport.

A flock of little flying fishes no bigger than herring, all in the air at once, gleaming blue and white silver in the sun, is one of the most beautiful sights of a tropical sea. The very thought of it takes one back to the broad blue expanse of trade-wind ocean, warm decks lurching under foot, spray singing through the shrouds, squawking tropic birds and bellying square-sails which swing against a background of fleecy cloud and sky.

In spite of their agility, flying fishes form the chief food of the little schools of oceanic bonitos, and of the dolphins, swiftest, most graceful, and most highly colored of marine fishes, which prowl over the high seas.

Ages before modern fishes, of which we now find such countless variety in tropical seas, had been evolved in the slow process of evolution there were sharks which differed comparatively little from those of the present day. Intermediate forms have become antiquated and dropped out, but the primeval shark (Color Plate, page 158) is still with us. Especially in the tropics they occur in great abundance.

SHARKS HUNT THEIR PREY BY THE SENSE OF SMELL

Prowling singly along the edges of the reefs, over the shallow flats, or through off-shore stretches of open water, they hunt largely by sense of smell and congregate in numbers wherever food is abundant.

When a whale is being cut up at sea, it is astonishing how quickly the slender, offshore blue sharks gather to the feast, it would almost seem from nowhere.

By far the most abundant sharks numerically are the ground sharks (*Carcharhinus*). There is probably no tropical or temperate coast-line where one or more species of this genus do not enter the bays and inshore water at the proper season to give birth to their young.

Though relics of a bygone age, as far as bodily structure is concerned, sharks, of all fishes, have the most highly developed reproductive system. Some lay a few large eggs, each one protected by a horny shell, but for the most part the egg stage



Photograph by John Oliver La Gorce

BENEATH THE SEA, AS IN THE AIR ABOVE, THE ETERNAL STRUGGLE FOR EXISTENCE IS WAGED RELENTLESSLY

A school of giant tuna feed on myriads of sardines. The tuna were evidently blood-mad and the white patches of water were occasioned by their great bodies breaking above the surface as they hurled themselves upon their prey. This is a graphic illustration of the never-ending struggle beneath the waves where the big ones eat the little ones and only the fittest survive. It is also an evidence of nature's safeguard against overproduction of species. The swiftly striking tuna charging with wide-open mouth causes the little sardine to jump for his silvery life, but, alas, the instant he shows as much as a fin above the surface, low-swinging gulls, or frigate birds, attracted from miles around by the disturbed waters, seize him from above. This picture was taken in mid-Gulf Stream and the area covered by the huge school of sardines was several acres.

is passed through within the body of the parent fish, and the young are born well grown and able to fend for themselves.

The black-tip shark (*Carcharhinus limbatus*) is a small species of ground shark, females of which are taken with young in the Bay of Florida in April. They are frequently hooked by tarpon fishermen, who erroneously call them "mackerel shark," and put up a spirited fight. They are usually between five and five and a half feet in length, and the young, about three to six in number, are two feet long, or a little less, when born.

We have data concerning another ground shark, *Carcharhinus milberti*, the brown shark, which gives birth to its young in Great South Bay, New York, in midsummer. The mother sharks are a little larger than those of the black-tip species, measuring six or seven feet. The young, however, are of about the same size, the only difference being that there are more of them in a brown shark's family, eight to eleven having been recorded for this species. Some kinds of sharks which grow much larger have a proportionately larger number of young.

While evolution has been molding other more modern fishes into a great variety of forms to fit every niche in the infinitely varied but unchanging environment of tropical seas, the shark has always been much as we find him today. He is a real hold-over from the far distant past, a sort of living fossil.

A FISH THAT UTILIZES A SHARK AS A TAXI

It is not surprising, therefore, that there is a fish which owes its very remarkable structure and habits to the presence of sharks. This is the slender shark sucker (Color Plate, page 158), which has the anterior portion of its body horizontally flattened and a remarkable oval structure, with movable slats like those of a blind on the top of its head. With this apparatus it attaches itself firmly at will to the shark's broad side and thus as a "dead-head" passenger is transported through long stretches of ocean without any effort on its own part.

The shark sucker is boldly and very beautifully striped with black and white, but can change its color almost instantly to a dull, uniform gray matching the side of the shark to which it is clinging. It sometimes attaches itself also to other large fishes, such as the tarpon, or to turtles.

A related species, the true remora, is found clinging to those sharks which swim through the high seas far from shore. A third is found clinging about the gills of spearfish or marlin. A fourth, with very large and strong sucking disk, has been found attached to whales.

All of these may, loosely speaking, be called remoras. They are sometimes erroneously spoken of as "pilot-fish," for the pilot-fish is an entirely different small species related to the amberjack, which swims in front of or beside sea-going sharks and is vertically banded with black.

THERE IS NOTHING ELSE IN THE WORLD LIKE THE REMORAS

Among the fishes of the world the remoras occupy the position of a genus with unknown ancestry. There is nothing else like them, and to what manner of fishes they may be related is one of the mysteries of old ocean.

Fish life of the shallow pools so often found along a rocky shore at low tide will repay careful study. Such a pool may be a few yards long, with a very irregular outline, full of nooks and crannies, and a few square feet of sand covering its lowest point.

Here the young of several types of fishes act out in miniature the drama which their elders are playing on the reef. Only the villains of the play, the larger predaceous fishes, are absent, at least for the present, until the returning flood inundates the isolated pool to make it once more a part of the big salt water, and we retreat up the beach.

The stage setting is extremely simple: the jagged blackish bottom of the pool, small area of gray-white sand, a little patch of brownish seaweed in one place, either growing there or drifted in at the last high water. From a distance half a dozen small fishes are visible, swimming actively about.

Nearer view shows them to consist of two or three sergeant majors, instantly recognized by the black and yellow uniform, in vertical stripes; a couple of Beau Gregoryses, with bright blue heads and yellow tails separated by a slanting line of demarcation, and a young wrasse striped lengthwise with black on a pale ground.

If one attempt to catch a fish of either of the former species, it displays great alertness and agility, dodging about the many projections and irregularities of rock. But



Photograph by E. R. Sanborn

WHEN ODD FELLOWS GET TOGETHER

The porcupinefish (above) can inflate itself into the form of a large ball. Its balloon shape and bristling spines then offer reassuring defenses against natural enemies. The hogfish (below), sometimes called capitaine, is beautifully colored and of excellent flavor. Many of the strange variations in the shape and defense equipment of undersea creatures are Nature's ingenious provisions for the several species' self-protection.

now we have the wrasse cornered and believe we have it in an instant, when suddenly it has disappeared.

Surely it did not dodge past and make good its escape in that way. Where can it be? Two or three minutes of careful scrutiny are rewarded. There it is, motionless, squeezed into a crevice of the side of the pool just large enough to hold it.

Swimming actively about, it was scarcely less conspicuous than the sergeant majors, but it has now, furthermore, changed color, so as to have a very low visibility in its sheltered nook. Here we have an illustration in detail of how various theoretical types of coloring work out. While swimming about with them the wrasse had a *conspicuous immunity* pattern like the sergeant majors; now, in the twinkling of an eye, it is a concealingly colored fish.

THE SAND FLOUNDER
DEFIES DETECTION

We have been speaking of fishes which no one will hesitate to admit are concealingly colored; but, lying in plain view on the sand, there is a little pale-colored sand flounder so exceedingly inconspicuous that it is unlikely that we shall see it unless the water is drawn out of the

pool and its inhabitants raked into our collecting bottles.

One thinks of fishes as leading a life of perpetual silence down there under the waters. This generalization is not in all cases true, however. Lying anchored in a small boat at night in Florida waters, one may sometimes hear a school of sea-drum go swimming by below. "Wop, wop, wop," they seem to say. Then there is the little trumpet-fish, so called, whose identity is open to question, technically speaking, that will at times lurk under the boat and intrigue you with its elfin tooting.

BY THEIR VOICES
THEY ARE KNOWN

Many species utter croaking or grunting sounds when caught, the several species of grunts owing their name to this habit.

Grunts are fish somewhat resembling snappers in appearance and to a certain extent in habit, but smaller and less vigorous. They are variously and artistically colored in grays, blues, and yellows. The yellow grunt (Color Plate, page 159) is yellow, with blue length-wise stripes. The common grunt has many narrow stripes of deep, clear blue on the head, the scales of the shoulder region enlarged and conspicuous, bronze in color,



Photograph from Roy C. Holliss

A JUMBO OF THE DEEP

Small wonder that an ever-growing army of business and professional men seeking relaxation from responsibility in their regular duties find a few days each season to run up to Maine and the adjacent Canadian waters to match their skill with mastodonic tuna, such as this 709-pound prize. Paradoxically, they find this entirely different type of hard work relaxing and beneficial. More and more wives, too, are becoming avid anglers.



Photograph by B. Anthony Stewart

CURIOUS FISHES INSPECT A MONSTROUS INTRUDER

At Marineland, an oceanarium 15 miles south of St. Augustine, Florida, visitors may view captive fishes and sea creatures through plate glass observation windows. Twice daily a diver descends to feed the specimens. A pronged glove protects his right hand as he feeds shrimp to a moray eel (with open mouth, bottom). The Marineland display has been built to reproduce as closely as possible conditions on the sea floor.

with grayish borders. The French grunt is light bluish gray, with broad, undulating, irregular stripes of yellow; and there are many other varieties.

Grunts have bright red or orange color at the base of the jaws and inside the large mouth. The color is not visible when the mouth is closed.

Sharks have been mentioned as an antiquated type of fish. In contrast with its conservative treatment of sharks in general, Evolution has made unusual and interesting creatures of the rays, which originally

were nothing but sharks flattened to lie on the bottom face down.

The skates which are abundant in northern waters are just this. Their breast fins have become fused with the flat sides of the body to form a disk, undulated at the edges as they swim, while the elongated tail, no longer used in locomotion, drags behind.

The sting rays are a more or less intermediate stage in which the tail has become a whiplike lash, with one or more jagged defensive spines at its base to ward off enemies. Finally the eagle-rays, still flattened, have become free-swimming again, the corners of their disks pointed like the wings of a bird, and used like wings to "fly" through the water.

One of these, the spotted whip

ray (*Aetobatus narinari*), has a very long tail lash, hard, paved teeth to crack the shells of mollusks, and is beautifully marked with pale spots or rings. It reaches a large size but not so large as the giant ray or devilfish (*Manta birostris*).

The devilfish has two peculiar fins, one at each side of the squarish head, which form a sort of funnel to entrap the schools of small fish on which it feeds when it rushes them in shallow water. When not in use these cephalic fins are rolled up to resemble two forwardly projecting horns.



MEALTIME AT MARINELAND SUGGESTS A SCENE FROM JULES VERNE

With a piece of food on the end of a pronged stick, the diver attempts to feed a sand shark and other big fishes without endangering his own limbs. The suspicious sharks usually stay aloof while the other creatures eat, preferring to feed later—and quite often on their small tank-mates!



Photographs by B. Anthony Stewart

WHEN THE DINNER BELL RINGS, HUNGRY BOARDERS COME ON FIN AND FLIPPER

Specimens at Marineland have actually learned to associate feeding with the clanging of a bell lowered into their tank. From a wire basket containing pieces of mullet, the diver feeds a sting ray close to his right knee. A sand shark noses past his left leg. Above the big jewfish resting on the bottom swims a large turtle nicknamed "Grumpy." Behind, four porpoises swing in for their share.



Photograph by James A. Allison

FROM TIP TO TIP, THE GIANT RAY MEASURED 22 FEET

The powerful 3,000-pound devilfish was towing the 25-foot motorboat bearing its captors at an estimated speed of 10 miles an hour when this picture was taken. Even after pulling the launch several miles, the mighty monster was still going strong. Tips of the winglike fins rise out of the water. Three lines ran from three harpoons that had to be brought into action before the huge ray was conquered.

DEVILFISHING IN THE GULF STREAM

Five Hours of Battle with a Giant Ray off the East Coast of Florida

BY JOHN OLIVER LA GORCE

WHAT the rolling prairie of the Far West was to the buffalo in the olden days, when it roamed in countless thousands to and fro in search of seasonal pastures and salt, the ever-rolling Gulf Stream—that mighty, warm river which parallels the east coast of Florida—is to the fish legions of our semi-tropical seas.

Few fishermen realize that there are found in the Atlantic Ocean offshore between Miami and Key West some 400 varieties of fish—a grand total which constitutes one-tenth of the entire marine fauna of the American Continent.

UNRELATED MONSTERS OF THE DEEP

To describe in detail the amazing variety of marine life along the Florida East Coast would overflow a five-foot shelf and I shall venture into no such survey but confine myself to the experience of our party in hunting and capturing a devilfish, one of the largest specimens taken in American waters in many years.

The devilfish and the octopus are frequently confused, whereas they belong to entirely different marine families. Indeed their only association is in the fact that they live in the same waters! The devilfish, or *Manta birostris* of science, belongs to the giant ray family—a huge batlike creature which uses its powerful body propellers as a bird employs its wings in flying, with a waving, undulating motion, which drive it along beneath the water at a remarkable pace.

Aside from its immense “wing-spread,” the outstanding feature of the devilfish, and the one from which it derives its satanic name, are the lobes, or, as they are sometimes termed, cephalic fins, which extend outward and upward from each side of its flat head like huge animated horns.

In the adult fish the paddlelike head fins are from three to four feet in length and from about six to ten inches wide. Nature has fashioned them of a leathery muscle tissue which spells strength in every ounce.

When the giant ray dashes into a school of fish, the head fins are of great assistance

in obtaining food, for, like the arms of a boxer, they are in constant motion, whirling about and sweeping living prey into a yard-wide mouth with amazing facility, as the giant hurls its body about in its natural element.

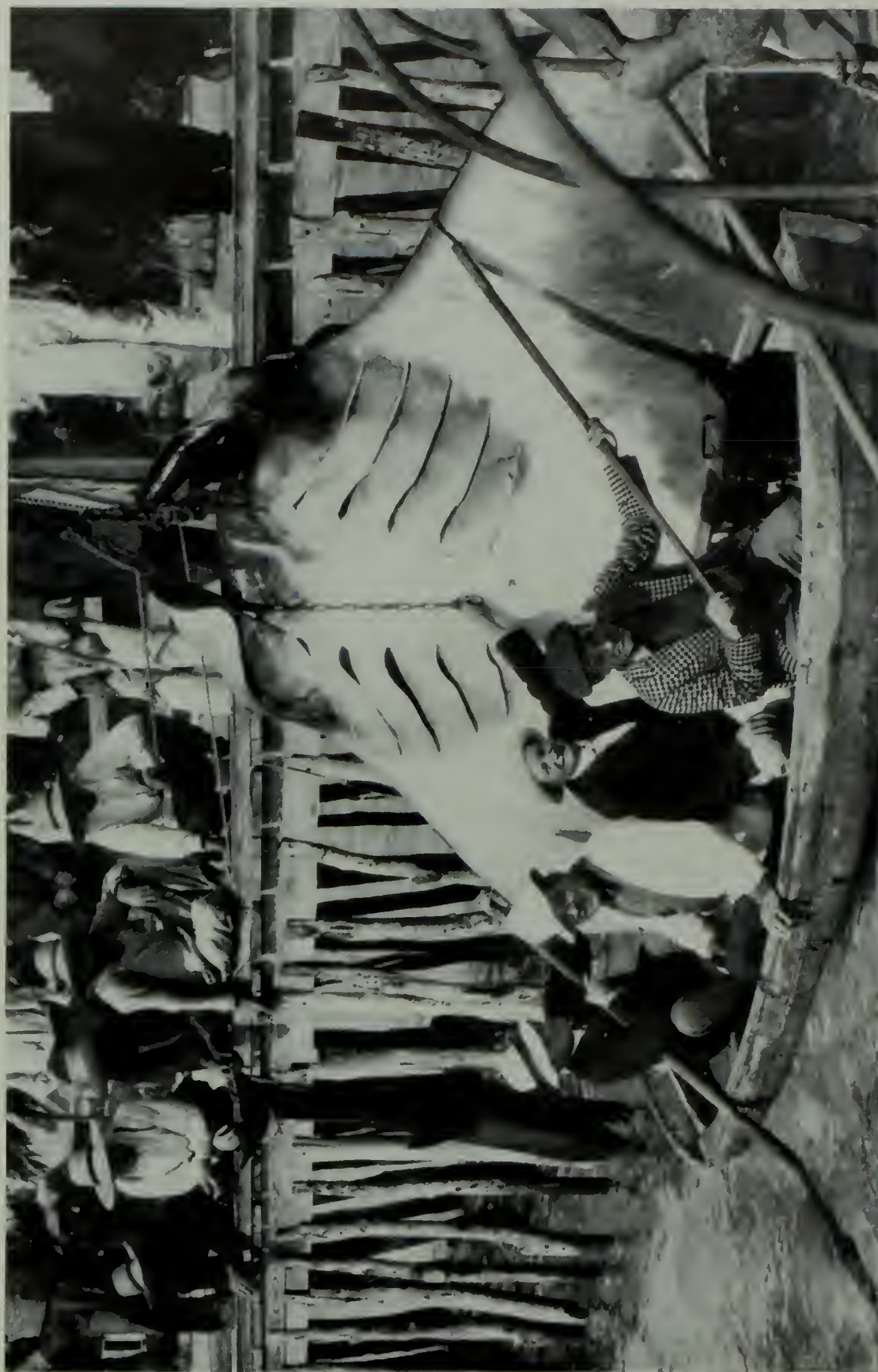
The remarkable strength and twisting movements of the head fins are responsible for the legends of this fish in olden times as a menace to mankind, whereas, unless attacked and in panic, the huge sea-bat seeks to harm no one in going about on its “lawful occasions.”

As a matter of fact there are reports of the devilfish’s running foul of a ship’s anchor chain. True to instinct, it clasps the chain by wrapping its tenacula arms about it, applies its tremendous strength, lifts the heavy anchor, and starts away with the anchor, chain, and ship, to the amazement and terror of the crew, who cannot believe their eyes as their vessel suddenly begins to move through the water without a sail set or an engine’s turning, when a moment before it was quietly moored to the ocean floor!

THE OLD MAN OF THE SEA GROWS TO ENORMOUS SIZE

The octopus (Color Plate, page 206), although sometimes termed “devilfish,” is of a different family entirely, an invertebrate, of the typical genus of Cephalopods, or, in simple words, the highest class of mollusca, in which squids, cuttle-fish, and octopi are known. In Pacific waters the giant octopus, technically known as *Octopus punctatus*, grows to astonishing size; indeed, specimens reported at rare intervals have measured a radial spread of 20 to 30 feet!

In appearance the octopus is most repulsive, having a large, ugly head, topped with two diabolical eyes set close together. These forbidding orbs are capable of sending forth a demoniac glare when the creature is aroused; and the fierce-looking mouth, armed with powerful horny jaws and shaped much like a parrot’s beak, is an object of terror. The grotesque head is mounted on a somewhat oval body, from which radiate



Photograph by Carl G. Fisher

RESEMBLING SOME MODERNISTIC HYDROPLANE, THE DEVILFISH HANGS ON THE WHARF AT BIMINI

Smiling and proud, the captors relax after the sea-duel. With its curling, hornlike head-fins (top), the devilfish, with a circular motion, sweeps live food by the bushel into its mouth when it dashes into a school of fish. The series of vents on the belly, which look like the hood over a gasoline engine, are in reality the breathing apparatus, or gills. Hanging from the wharf on the left is a herring-hog, a species of porpoise.

eight arms, usually united at the body base by a tough membrane. The arms or tentacles are provided with rows of disc-like suckers, with which it seizes and clings to its prey with uncanny tenacity.

Generally speaking, it will not give battle to man unless angered or injured, but when challenged will fight to the last, doing its best to pull the object of its wrath beneath the surface of the waters.

THE START FOR THE HUNTING GROUNDS

From the Florida reef the run across the Gulf Stream to the nearest islands of the Bahamas is a matter of only 50 miles. We started from Miami Beach one afternoon, aboard the sea-going motor yacht *L'Apache*, with a 25-foot motor-driven fishing boat in tow bobbing along behind.

In the party of fishermen were James A. Allison, Captain Charles H. Thompson, of Miami, an authority on the fish of the warm seas; Commodore Charles W. Kotcher, A. G. Batchelder, Carl G. Fisher, and the writer.

Favored by the northeastward urge of the ever-moving Gulf Stream, we made fine progress, and about dark cast anchor in the harbor of Bimini, a tiny island resting like a jeweled feather on a summer sea, the westernmost outrider of the Lower Bahama group. Our goal was North Bimini, the quaint little sand and coral dot four miles long and from a few hundred yards to nearly a mile wide, covered with clusters of coconut palms and tropical plants, its tallest headland rising but a few feet above the surface of the Atlantic. It was then an out-of-the-world spot peopled by a few score of Bahama negro families, who eked out a precarious existence by fishing, gathering conch shells, sponges, and, in a small way, cultivating sisal, the fibrous plant from which rope is made.

Of late years Bimini has bloomed out and today sports a small, but comfortable, hotel, a fishing club, and a few modern residences and shops. It annually attracts an increasing number of big game fishermen from the States and Europe to hunt and capture the heavyweight fighters of the teeming warm seas. The widely publicized fishing tournaments staged annually at Bimini produce new record catches of giant blue marlin, tuna, and other varieties of bigsters such as men dream of and boast about.

As we approached the island, the sea bottom for several miles offshore was seen car-

peted with white sand, and so clear is the water that there is no difficulty in glimpsing the marine gardens 30 to 50 feet below the surface.

Because of the sand bottom and the glorious blue of the sky, together with the tropical sunlight and the ever-changing cloud effects, the bewildering gradations of color to be seen in these waters challenge the skill of the artist, although he paint with the brush of genius.

The Bahamas are a colony of Great Britain and of course British authority extends even to this tiny coral dot. Bimini boasts a port officer—an Englishman, who then also served as the Crown Commissioner, Police Magistrate, Customs Collector, and Consular Official for examination of passports, as well as being physician and school teacher to the island's inhabitants. He was a sort of Pooh Bah, who, with cordial dignity, met the occasional foreign craft when it dropped anchor in the harbor, inspected all qualifying documents, expected an invitation to dinner, and later sadly waved adieu when the visitors sailed away. While the usual rules of a foreign port are observed, alas, a good deal of the islands' quaintness of early years has been lost in the streamlining of the Bimini of today.

FOR MANY GENERATIONS THE SEA FED THE BIMINITES

For many generations the sea furnished most of the food for the native Biminities of ebon hue who supplemented their meager larder by raising indifferent patches of corn and peas and now and then getting a few other fresh vegetables, flour, and salt meats, when periodically a supply boat put in from Nassau a hundred and thirty miles away.

Conch, the marine animal which inhabits the beautiful spiral shell, was then a staple article of food, of which the island folk consumed thousands each year, easily gathered from near-by tidal sand banks and made into soup or eaten raw.

After we had received the official call of the Crown's Representative and, noting the expectant look in his eye, asked him to dinner, we had visits alongside from small shore boats, manned by dusky merchants. Each hopeful tradesman, with an ingratiating grin and a decidedly hungry look, offered for sale varieties of sponges, brilliantly colored conch shells, sea-beans, and tortoise



Photograph by John Oliver La Gorce

IT TOOK BLOCK-AND-TACKLE TO BEACH THE HUGE RAY

Native black boys of Bimini, in the Bahamas, helped haul the big prize ashore. After almost five hours of battle, the ton-and-a-half creature still had enough life left to make towing difficult, even with a power boat. Finally, it was necessary to administer the *coup de grâce* with several rifle shots and then the devilish was successfully brought to land. It was mounted and exhibited in an aquarium for several years.

shell, the latter obtained from the hawksbill turtle, which is frequently taken in Bahama waters.

It was like pulling teeth to go below and leave the beauty of the tropical night, with the soft, cooling touch of the ever-blowing trade wind, the shadowy grace of the giant coconut palms swaying and whispering in the moonlight on the near-by beach, while the surf, grounding upon the coral strand of the outer harbor, lulled with its crooning obbligation.

But wiser heads spoke of the need of a good night's rest to prepare for the battle royal which we hoped was in the offing, and we regretfully turned in instead of having a try at the tarpon which could be heard jumping and rolling like playful puppies on the harbor surface a few hundred yards astern.

At sunrise next morning all hands turned out ready for the fray. The chef soon had a hot breakfast served, after which we piled aboard our motor-driven fishing boat, upon which rods, lines, and harpoon gear had been made ready.

Making a course to sea out through the island channel, all save the steersman hung over the side to enjoy the amazing sights in the deep tidal pools. One would excitedly point to a squad of six or eight big tarpon lazily wallowing about far below—lords of their element, unafraid; therefore ready to give running battle to anything except, perhaps, a tiger shark.

THE CHANNEL A NATURAL AQUARIUM

Another startled angler would call out that a 10-foot hammerhead or a nurse shark was rolling an eye at him from the harbor floor, while still another inland fisherman wanted to jump down among a school of hundreds of large and small mangrove snappers busily parading up and down a long stretch of coral shelf which afforded them instant hiding places upon the sudden appearance of hungry enemies. The clear water made the harbor channel a natural aquarium.

Over the bar and outside all hands were soon scanning the heaving swell of the Gulf Stream for big game, like the crew of a destroyer peeling their eyes for a periscope in a wartime danger zone.

Oddly enough, the noise of a propeller seldom frightens the large fish of the warm seas. If they are attracted by the trolling bait or are not disturbed by the approach

of a natural enemy below water, one can not only get close up, but will have little difficulty in keeping some of the surface hunting fish in sight, once they are located and something of their habits known.

After a bit Captain Thompson called attention to a long, dark shadow not far below the surface and the boat was turned toward the first sign of a quarry, which turned out to be a herring-hog, a large species of porpoise. It proved to be an adult about seven feet long, weighing around four hundred pounds, and as this species destroys great quantities of foodfish, we went for it.

The proper position to strike having been reached, a hand harpoon was thrown which found its mark, and away the herring-hog went at a fast clip. One of the less experienced fishermen of the party, who rated a little hazing, was given the harpoon line with orders to bring the big fellow alongside forthwith, and further advised to "keep his head up and not let him drown," the rest of us sitting back to enjoy his strenuous but futile efforts to obey!

THE REAL BUSINESS OF THE DAY

About twenty minutes after the strike and while yet the herring-hog was demonstrating no signs of tiring, although this could not be said of the perspiring amateur fisherman who was quite ready to toss in the towel, a disturbance was observed on the surface of the water about a quarter of a mile away. It was thought to be either a leopard shark at kill or a battle royal between two big denizens of the deep. Anything can be expected in those waters!

It was our business, however, to have ringside seats at this battle, whatever it was. All hands then took hold of the harpoon line and, reversing the engine, which was not very sportsmanlike, but decidedly effective in checking the porpoise, we brought him alongside without further loss of time, finished him off, and then turned our attention to the mystery now close at hand.

We were all excited at the thought of perhaps getting a harpoon into a big leopard shark, which will fight any and everything that swims, and, according to authorities on marine life, is one of the several members of the shark family dangerous to man while in the water.

But the reader can imagine how our excitement was increased when suddenly Captain Thompson, who, having uncanny eyesight plus long experience with sub-sea



Photograph from Pictures Inc.

A FAIR FISHER ACHIEVES A WORLD RECORD

Each year the lure of matching wits and skill in combat with the giants of the open seas attracts a greater number of the gentler sex. During the summer of 1939, Mrs. Henry Sears (left) of Greenwich, Connecticut, won the distinction of landing a 730 pound blue marlin on a 24-thread line in a one-hour-and-thirty-minute fight, thus establishing a new world record. The battle took place off Cat Cay in the Bahama Islands just across the Gulf Stream from Miami Beach, Florida. Mr. Thomas Shevlin, previous world record holder (636 pounder), stands at the right with Mrs. Paul Sanborn, who had held the woman's record (560 pounder).

life, suddenly exclaimed: "Stand by, men; it's the biggest devilfish I've ever seen!"

As we drew near, it seemed to me that a big patch of the ocean floor was suddenly dark and moving off, for I saw in the translucent depths a gigantic shadow which had the appearance of a prehistoric bird flapping its wings and swinging its long, thin tail from side to side, as it "flew" slowly along.

While we were coming up to the fish, which was evidently swallowing something it had killed and was paying no attention to anything else, the gear which we had used in capturing the herring-hog was made ready for action. At the right instant Captain Thompson let fly with his heaviest harpoon, and then things began to happen sure enough!

Not a man of us in the boat was ready for the extraordinary events that followed. The devilfish came up as if hurled by a submarine explosion. One of its great, curling, batlike fins flashed out, sending gallons of water over us and splintering the harpoon pole against the boat's side as if it had been a match stem; then its 10-foot pectoral wing struck the water with a terrific impact, making a noise which could have been heard a mile away.

For a moment the monster seemed bewildered; and that lost moment cost it dear, for the pause enabled us to throw another harpoon, which struck deep into its body. Away it started, taking our harpoon lines out at a pace which made us apprehensive, although a moment before we had thought there was a wide margin of line. All hands put their weight on the lines, and as the boat was by this time moving on a more even keel, we took a wrap around a bow cleat and started for the horizon—giant fish, boat, and crew!

THE HUGE MONSTER LEAPED CLEAR OF THE WATER

Several times the devilfish hurled itself out of the water, and its huge body would come down with a crash like the explosion of a depth charge. Moreover, each time it broke the surface it looked larger than ever! Now and then it would sound for deep water in an effort to shake us off, and our lines paid out so near the ends that Thompson stood by with a hatchet to cut them in the event the bow should be drawn dangerously under water. This came uncomfortably near to happening more than once.

All of a sudden the lines slackened, and we frantically hauled in as the monster turned and dashed toward us, coming up almost, but not quite, under our craft, its great bulk lifting one side of the heavy launch well out of water and giving us a pretty stiff scare.

With seasoned skill and knowledge of sea battles, Captain Thompson let drive another harpoon, which found lodgment in the devilfish's head, and away it dashed again. With three harpoon lines, one in each side of the body, and another in the head, it was possible at times to drive the monster as one would a runaway horse, swerving it toward the shore of Bimini and into more shallow water by the process of pulling first on one line and then on the other. The operation was a little too much for the big fellow to buck against.

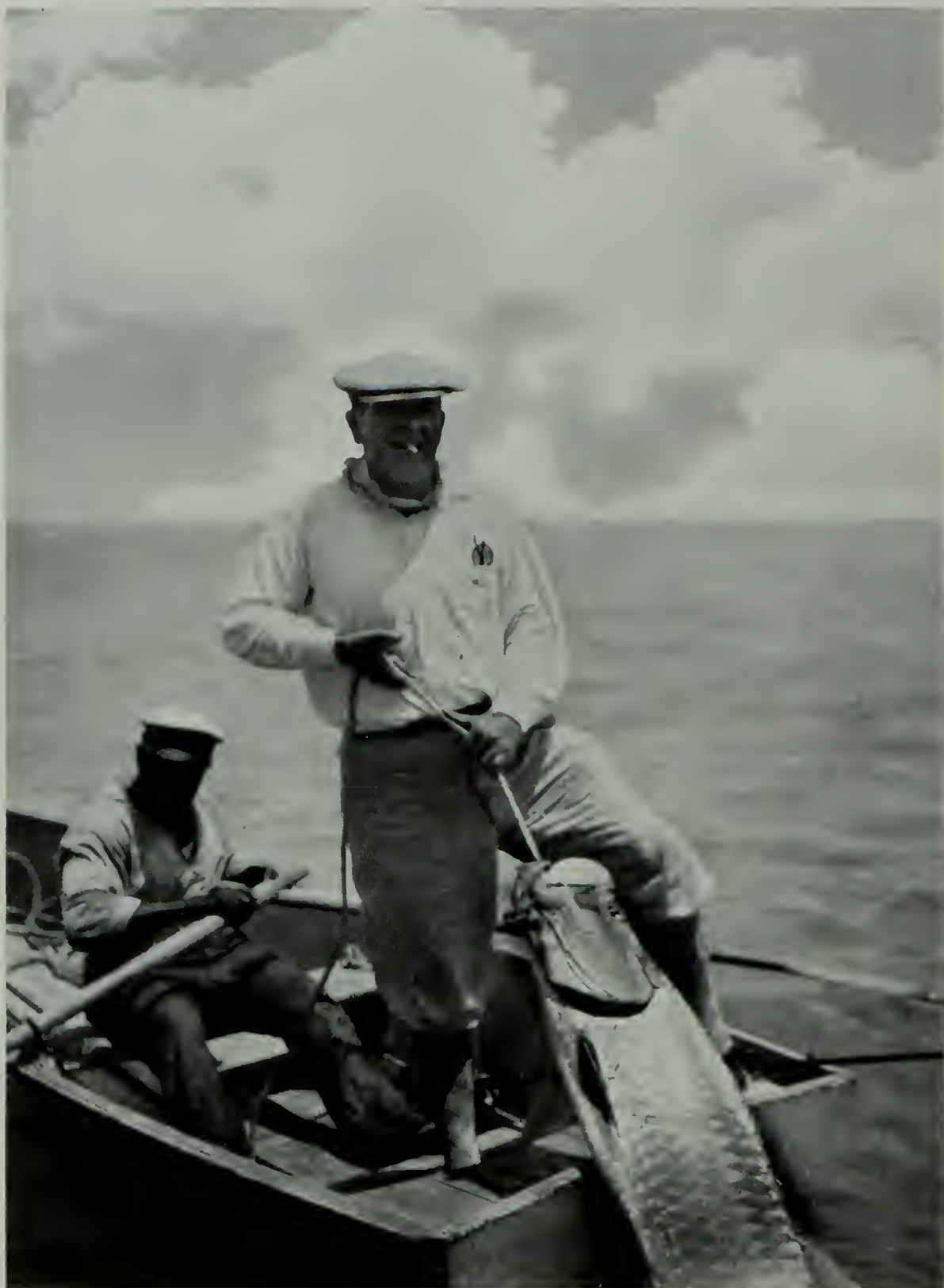
THE 3,000-POUND FIGHTER FINALLY BEGINS TO TIRE

By this time the devilfish had towed us for several miles, and although losing blood, it was still going strong. Our next experiment was to throw out the anchor in the hope that this maneuver might further slow things up. But this expedient made little difference to the giant, for it continued to pull us along as if our heavy boat was but a birch canoe.

After an hour or so during which the devilfish alternated between trying to pull the bow under water by a "power dive" or suddenly turning and endeavoring to come up under us, we maneuvered into more shallow water. The anchor began to take hold, and our giant became a little more amenable to reason, so that a number of times we were able to haul in slack, recoil our lines. Eventually we approached within 20 or 30 feet of the creature, as it propelled itself along with its ten foot wings, a little less powerful in stroke and somewhat slower, all of its huge body in plain sight, five or six feet below the surface of the water.

It was at this point that we calmed down sufficiently to make pictures, which we believe were the first actual photographs of a giant devilfish alive in its natural element (see page 168).

These photographs, because of the refraction of light in the water, do not give a clear idea of this fellow's size, and from them it is somewhat hard to realize that our captive measured 22 feet across from the tip



Photograph from John Oliver La Gorce

BATTLE FROM A ROWBOAT GIVES THE FISH A SPORTING CHANCE

Victory marks the end of a battle royal down the Florida Keys. The "silver king," as the fighting tarpon is affectionately termed, had much to do with establishing south Florida as a Mecca that lured fishermen to those waters from all over the world to try their skill and luck. True sportsmen, when successfully bringing these gamblers alongside, release them unharmed unless they are really injured in the fight and would become the prey of ever-present sharks.

of one pectoral fin to the other and 17 feet 1 inch from the head to the end of its tail, and that it weighed more than 3,000 pounds.

Seeing that it was well-nigh impossible to give the battler a quick death blow, and that at any minute in its jockeying the fish might come up squarely under the boat and upset us among a number of big sharks that had been attracted by the struggle and presence of blood, we did not relish the thought of thus having the tables turned.

VICTORY AFTER HOURS OF BATTLE

Luckily, about this time, a fast-sailing little island sponge boat approached to see what the excitement was all about. We managed after a little difficulty to make the spongers understand that we wanted them to go back to the yacht and send out a rifle. This necessary item of equipment had been forgotten in our hurry to get started in the early morning.

The native mariners were most willing to help, and made all haste possible shoreward. After another hour of skirmishing and ring generalship on both sides, the yacht's motor-driven dory came tearing out with an express rifle and we were able to give our gallant foe the *coup de grâce*. Our use of a bullet to quiet the devilfish perhaps was not sporting, but under the circumstances it was the only solution of our problem. Continuance of the now unequal contest would have been cruel in the extreme.

Until then not one of us realized that nearly five hours had elapsed since we first tackled this Jumbo of the deep, nor did

any of us realize how tired we were. We had been far too busy to give a thought to such small matters. The struggle had taxed our strength to the utmost and left us physically and nervously near to exhaustion.

Although the fish finally had three harpoons and several 30-30's in its body, it was not entirely dead and we had considerable difficulty in towing it into the distant harbor. The tenacity of life displayed by this embattled giant of the deep seemed almost incredible.

The Bimini fisherfolk were greatly interested in the capture, for devilfish were seldom seen, much less captured, thereabouts, and we had no difficulty in getting a dozen black boys to help get the captive ashore.

NEARLY WRECKS THE WHARF

By bringing into play a heavy block and tackle which was used for hoisting cargoes of sisal fiber, and after much breaking of ropes, to say nothing of the none-too-strong wharf structure's being in serious danger of collapse because of the great weight of the fish, we finally succeeded in getting most of its body out of water, so that it could be photographed and weighed by means of a large sisal scale. The limit of this scale was 3,000 pounds, and this was all we claimed for the fish, although we judged it weighed 4,000 or more.

It was a grand battle, full of thrills for each of us although a little tough on the devilfish. We wanted the monster for scientific study and upon our return to Miami it was successfully mounted by a skilled taxidermist and exhibited in an aquarium for several years.





Photograph by John Oliver La Gorce

HUNTING ITS PREY, A BARRACUDA SLINKS SWIFTLY OVER THE GOLDEN SANDS OF THE GULF STREAM

So clear were the waters and so bright the white sands along the Florida shores that it was possible to snap a picture of the "tiger of the seas" from a boat. The five-foot predator was swimming more than six feet below the surface. Because of the splendid illumination afforded by the sunlight reflected from the glistening sand, even the shadow of the fish was recorded, as well as the little tufts of sea flora.

CERTAIN CITIZENS OF THE WARM SEAS

In the Struggle for Existence, Fishes Fight Wars Continuous and Everlasting

BY LOUIS L. MOWBRAY

Curator, Bermuda Government Aquarium

MAN'S most terrific wars against his fellows have a respite; they are but cataclysms in the normal course of the world, but the battle of fish against fish—furious, quarterless and to the death—is everlasting.

Within the warm waters of the Gulf Stream off the the coast of Florida, where the lazy waves of the surface seem to typify peace, the never-ending Armageddon of the finny world rises to its highest pitch. It is almost impossible for the human mind to imagine the continuous struggle for existence that goes on beneath the surface of the water in these and other seas. If such conditions existed on land, and the resultant mental strain were not provided for by Nature, few would survive the constant tension on the nervous system.

SAVAGE FISH PREY ON THE WEAK

A fish pursuing another frequently attracts the attention of one of a larger species and is in turn pursued. Or, as often happens when an angler hooks a prize, it is cut in two by the jaws of a larger enemy before it can be drawn into the boat. Apparently most carnivorous fishes sense prey the instant one of their number is in trouble, and the blood lust becomes epidemic forthwith. And so, on and on, will it be to the end.

The strife of the seas takes many other angles, of course. Fishes that feed in "schools" have a well-planned method for acquiring their living food, and the same procedure is carried out so often that the maneuvers resemble the operations of an exceptionally well trained body of soldiers.

When a school of smaller fish is located, the larger fishes encircle them and herd them into an almost compact mass, and occasionally dash in to get a mouthful for food and to keep them in a state of panic.

During the melée the surface water is lashed into foam by the mad efforts of pursuer and pursued. Often an area exceeding a mile square will be thus stirred up, and it is such a conspicuous sight that it

may be seen for many miles. Consequently, other menaces to the existence of the victim fish are attracted to the vicinity. These are seagulls, terns, man-o'-war birds, pelicans, and fishermen. The former swoop down from the skies, and the latter from all sides, with the single purpose that means, so far as the fish is concerned—destruction.

It is possible to locate a shoal of fish even deep in the water by watching the actions of the birds which feed from the sea. Their keen eyes observe a dark "shadow", and their cries attract other birds to the vicinity, where they will hover until the inevitable attack from below by larger fish drives the smaller ones to the surface.

In addition to sheltering nearly every species of sea creature under the laws of chance by providing extreme prolificness, Nature has not failed to furnish other protective measures to offset somewhat the dangers that everywhere threaten to eliminate whole species.

Numerous instances are recorded where a certain kind of fish has been almost obliterated, and for long periods has been thought to be extinct; but in some manner enough individuals of the species remained to find sufficient protection to live and propagate their kind.

COLD WATER ALMOST WIPED OUT THE TILEFISH CLAN

One case is that of the tilefish, an important food fish which inhabits the depths along the edge of the Gulf Stream. In 1882 vessels arriving in Philadelphia, New York and Boston, reported having passed through miles of dead fish of this species. From the accounts received it was estimated that an area of from 5000 to 7500 square miles was thickly strewn with the dead and dying fish.

Various reasons were advanced for this gigantic tragedy, the most plausible being that a very sudden drop in temperature along the western edge of the Gulf Stream proved fatal to these warm-water fish. It seemed for several years that the species



Photograph by James A. Allison

TAKEN ALIVE, A SAWFISH BECAME AN AQUARIUM ATTRACTION

This specimen was exhibited for several weeks in a 36-foot tank at Miami Beach. While in captivity, she gave birth to nine young, which were kept alive for several months.

was almost totally wiped out, but evidently nature's balance reasserted itself and fortunately tilefish have been re-discovered in great numbers in their former habitat. It is not known where they retired until their numbers became strengthened, but the fact remains that this valuable food fish is back again in normal abundance.

FRY PLAY ABOUT SUNKEN WRECKS

Amidst the coral reefs off Florida one frequently sees millions of the fry (or young) of some pelagic or surface-swimming offshore species taking shelter in and about the skeleton ribs or plates of a wreck resting on the ocean bottom, yet easily discernible in the clear waters. Not only does the structure of the abandoned ship afford a hiding place for the fry and small fish, it furnishes a home for various members of the large grouper family.

The groupers are "guards" for the smaller fish against their arch enemies the jacks and yellow-tails which in turn become prey for them. The fry thus frequently remain unmolested, since they are too small to serve as food for the groupers.

When the fry move from place to place,

they usually do so at dusk or during the night, and then only near the surface where they find their principal food—plankton, the weak, floating organisms, and nekton, the actively swimming animal life—which is more plentiful there after the sun's rays are lessened.

Many fishes of the warm seas are chameleonlike in their coloration and adopt the colors or hues of their surroundings for protection, while others seek holes and crevices into which larger fish are unable to follow. Still other species, to insure the hatching of their progeny, carry their eggs in their mouths.

Nature has so taken care of some species that they are hermaphrodite. Others live in the gill cavities of greater fish, partaking of the food and protection which the larger affords. This is a common occurrence in the relations of some species of the sucking fishes to the mola, or giant sunfish, the sailfish, and the marlin.

Many live in other marine animals. For instance, the amia, a beautiful red fish about two inches long, lives with the animal in the shell of the large West Indian conch (pronounced "conk"), *Strombus gigantus*.



Photograph by Capt. F. G. Lancaster

TWENTY-FOUR BABY SHARKS WERE REMOVED FROM THE ABDOMEN OF THIS MOTHER

Sharks are frequently captured off the Bahama Islands, where this one was taken. Often they are harpooned while floundering about after crabs on the shallow sponge banks.

While finding protection there, this little fish carries its eggs in its mouth. The fierasferer lives in one of the holothurians, or sea cucumbers.

Into the battle for and against the multiplication of the many species in the sea steps man, who looks to the sea for food, for recreational diversion, and for other benefits. Industries have been built up which take countless millions of fish yearly for food and other commercial uses.

It is doubtful if there is any one except the biologist who appreciates the living things in the sea more than does the sportsman, who comes to the fishing grounds to indulge in this healthy out-of-doors recreation.

"BUCK FEVER" GRIPS THE FISHERMAN

The big-game hunter of the land, in coming upon a bull moose standing clear of the woods and providing an excellent opportunity for a shot, will sometimes tremble so much that he is unable to pull the trigger of his gun.

So it is with big-game fishing. The thrill and suspense are so terrific when one is watching a huge marlin or tarpon or other

large fish, that at the moment of the strike the angler is temporarily bewildered. Equal thrill may be had on the smaller species, of course, and it is truly said that even one strike invariably wins a convert.

Wary, strong, and of remarkable game-ness, these salt water fishes try the skill, strength, and endurance of even the best and most experienced angler. While some prefer the tarpon, others swear by the bonefish, wahoo, sailfish, and marlin as being the gamiest prize. Each has actions when hooked that appeal to anglers in different ways. All admire the bonefish and wahoo for their extreme speed and gameness, and the tarpon, sailfish, and marlin for their wonderful leaping in trying to free themselves from the hook and restraining line.

The tarpon (Color Plate, page 202) is abundant on both coasts of Florida and in Texas. There are also many to be found in Cuba, and, quite rarely, Bermuda. Hundreds of sportsmen, in both winter and summer, fish for this species known as the "silver king." In appearance, it resembles a gigantic herring and it reaches a weight of more than three hundred pounds. Its scales, large and iridescent, are utilized in



Photograph by A. W. and Julian A. Dimock

OUT SHAKES THE HOOK AS A TARPON DEFIANTLY LEAPS FOR FREEDOM

Lost by the fisherman, the "silver king" was caught by the camera genius of the pioneers in this field of photography. "Fishing provides the only opportunity for modern men to do real thinking undisturbed," President Cutten of Colgate University has said. "It offers a real escape from the complexities of modern life. After a few hours with rod and reel, the angler returns to work refreshed in mind and body."

the making of many fancy articles which find a ready market as souvenirs of the habitat of the tarpon. When mounted, the fish makes an eyefilling trophy on the wall of a clubhouse or fisherman's den.

Two other Atlantic fish which are on a par are the sailfish (Color Plate, page 203) and marlin (Color Plate, page 207), the former being responsible to a great extent for the tremendous interest in sport fishing which began thirty-odd years ago, and which today represents probably the greatest outlay in equipment in the entire world of sport.

The sailfish is a sporty and game fighter and is one that should be caught with light tackle in order to bring out its best points. The greatest area in the Atlantic for the largest numbers of these fish is from well above Palm Beach to Key West, Florida. They are more numerous in the waters around the Galapagos Islands than in most other places in the Pacific.

The white marlin is similar to the sailfish in its habits, and its range of size is about the same. In northern waters one

place of its greatest abundance is off Ocean City, Maryland, where hundreds are caught each year during the summer months.

The other species of marlin, known as the blue, striped, and black marlin, grow to a much larger size. They are considered today, along with the mighty swordfish and bluefin tuna, to be the best and greatest game fish in the seas. They are found in practically all warm waters, and are especially numerous around Bimini, Bahamas, the west coast of Mexico, Southern California, and New Zealand. Marlin have been taken weighing more than 1000 pounds.

FISH NAMES HAVE MEANING

The marlin or spearfish, as it is also called, derives its name from the sharp, protruding snout and its likeness to a marlin-spike and spear, just as the sailfish gets its name from its sail-like dorsal fin, which is frequently seen "hoisted" on calm days when it is feeding on the surface.

The purpose of the hard bill is to smack and stun the victim, and this is done by



Photograph by L. F. Williams

IT HUFFS AND IT PUFFS TO SCARE ENEMIES OFF

By self-inflation, the swellfish, or puffer, becomes more formidable-looking. When blown up, even a small one can bear a man's weight without bursting.



Photograph by W. H. Longley

AMONG GORGONIAN "FORESTS" SWIM DOG SNAPPERS



Photograph by John Oliver La Gorce

MIGRATING PORPOISES LASH THE OCEAN SURFACE

In great schools, the graceful creatures move up and down the Atlantic coast. They are said to devour their weight in fish every 48 hours.



Photograph from Miami Aquarium

A HUNGRY SHARK OR BARRACUDA ROBBED THE ANGLER OF HALF HIS CATCH

While the muttonfish was being pulled in near Miami, the undersea vandal struck.

striking the prey a sidewise blow by a shake of the head. This is characteristic of both the marlin and sailfish, and also the swordfish.

One of the features which makes the marlin such an interesting fish to catch is its performance, when hooked, of a stunt called "tail-walking." The fish will rise above the surface and keep its body nearly erect by a terrific wagging of its tail, and move at great speed for fifty yards or more. Such a show is a sight that is never forgotten.

Another of the great game fish, the bluefin tuna (Color Plate, page 54), is also found in the warm seas around the Straits of Florida. Only very recently were fish of this species "discovered" migrating in great numbers along the southern edge of the Gulf Stream. They appear there during May and June moving northwest.

At this stage in their migration they are invariably lean and amazingly strong. Fish of equal length, when caught off Nova Scotia three months later, after fattening on herring and mackerel on their way up, will weigh two hundred pounds more than they did off Bimini, and are therefore sometimes a little less difficult to boat. The maximum size of the tuna is not known, but it is not far from 2000 pounds in weight and more than twelve feet in length.



© Erl Roman

PRIZE TO BE PROUD OF IS THE FIGHTING WAHOO

This captured scrapper of many tropical seas is highly respected for his gameness. The photograph was made within a few seconds after the fish was removed from the water; therefore its stripes are plainly seen. The markings disappear not long after their wearer's death.

The Allison tuna, which was first caught off Miami Beach in the early 1920's and named by the writer for James A. Allison, the founder of the old Miami Beach Aquarium, is not so numerous as the bluefin. However, it is an even gamier fish and for those who like really hard work in their fishing the Allison is the best obtainable anywhere. Its greatest weight probably does not exceed six hundred pounds and the average will be about a hundred. The first specimen taken in Bermuda was caught in 1936, and since that time the species has been found to be



Photograph from Dr. J. Lawn Thompson

MIAMI BEACH SPORTSMEN DISPLAY A DAY'S CATCH

The giant jewfish, suspended above, is eight feet long and six feet four inches in girth. On the rack and lying on the dock are amberjack, dolphin, barracuda, grouper, kingfish, and mackerel. All but the barracuda are edible. Such generous catches are frequently sent to hospitals or hotels.

quite numerous there. January to October seems to be the period in which it is most frequently caught.

A striking feature of the Allison tuna is its beautiful gold and blue coloring. The fish is instantly recognizable by this coloring and by the extremely long dorsal and anal fins.

Of the smaller game fishes of the deep sea, the dolphin (Color Plate, page 200) must be mentioned in the front rank. Much has been told of this beautiful species, and by the speed-loving American it is looked upon as one of the greatest of fishes, for there are indeed very few

citizens of the deep which travel so swiftly. It spends its entire life in the open seas, and is found often near patches of sargasso weed, in which lives a considerable portion of its food.

While it is idling, its movements are sluggish, but when in quest of prey it darts with incredible rapidity, and to one observing its movements it appears like nothing so much as an arrow of color in the sea—a yellow-blue-whitish streak that is almost lost in the blue water.

THE DOLPHIN BEAUTIFUL WHEN DYING

Of all deep-water fishes, the dolphin possesses the greatest power to change its color. A dying dolphin affords a most beautiful and spectacular sight, when, with all the iridescence of an opal, it changes hue so rapidly that the brain cannot grasp the beauty of one color before another comes into view. In life, its general color is of blue or emerald green on the upper parts, with brighter blue dots showing through; the belly is silvery, and the caudal and pectoral fins are a clear golden-yellow.

It is an excellent food fish, but, not being found in large numbers generally, it has limited commercial value. It is caught usually only by chance, when one is fishing for other game fish which inhabit the same waters. Dolphins seldom refuse a bait if it is moving, and their sight is incredible. On many occasions the author has seen a dolphin leap twenty feet or more to land directly on a bait that is being trolled. They are game but not very strong fighters and are fish that should be caught on very light tackle to be appreciated.

The real game-cock of the salt water, of which there is only one species, is the bone-

fish (Color Plate, page 201), and it is to be found in all warm and tropical seas. It is considered to be among the most indefatigable fighters of fishdom and is a source of much sport and conversation to the angler, who will often travel hundreds of miles to match wit and skill with this worthy opponent. Its name is, like most common names of fishes, derived from its most striking feature. Its bony structure is similar to that of the herring.

In the localities where this fish abounds, the natives have a way of stretching it before cooking, so that the bones may be loosened from the flesh. When cooked properly, after this operation, it provides a fine dish and the bones may be easily drawn out.

In the West Indies and Florida it may be seen in considerable numbers feeding along the many shallow sand-banks and underwater grasses. On an incoming tide bonefish ride to feast on the many worms, mollusks, and crabs which have been left stranded and weakened by the previous low tide.

Quite the contrary is the case in the waters about Bermuda. Bonefish are seldom seen during the day, and come into the bays and inlets only at night to feed. Early evening is the best time to fish for them there, though it is not infrequent to catch one in water twenty or thirty feet deep during the day when fishing for snapper. The average weight for these fish in Bermuda is from eight to ten pounds, and in Florida and near-by waters the average is about three to six pounds. Their greatest weight is nearly twenty pounds.

A GOWN MADE OF BONEFISH SCALES

The writer has seen an evening gown made wholly of bonefish scales. It was a thing of beauty, indeed. The scales were drilled and fastened upon a fabric base like shingles on a roof, and the resultant effect was like that of the natural body of the fish.

A very interesting and dignified-looking fish is the moonfish (Color Plate, page 197). Of all the silvery-colored fish there is probably none which is more beautiful. They frequent shady places and sandy shores where they may be seined in considerable quantities. They are highly esteemed as a food fish and as such rank with the pompano.

The peculiar moonlike shape of the fish



Photograph from Alfred Sanford
FROM FLORIDA WATERS CAME THIS
158-POUND TARPON

The species was one of the first "discovered" by American sportsmen. Consequently, it has been much advertised and is still the most widely-known salt-water game fish. The "silver king" is also caught on the shores of the Gulf of Mexico and in some of the West Indies. In Cuba it is taken in tidal streams.

is mainly responsible for its name. They are literally the "highbrows" of the fish tribe, their high forehead giving the appearance of intellectuality. To a quiet observer they appear to be duly appreciative of the fact that they are admired, for they seem to be forever preening and cleaning themselves in the sands.

When seen at close range, the iridescence of their silvery bodies is more beautiful than mother-of-pearl, which the sides of the fish so closely resemble.

Many other fish are given names which are familiar on the land, and mainly for their resemblance in looks or habits to some form of animal life on the earth. A few examples are the dogfish, the catfish, and the hogfish. The dogfish gets its name from its fearlessness and tenacity when hungry; the catfish, from its "whiskers"; and the hogfish from its peculiar snout, which greatly resembles that of the hog.

Probably the most heard-of of these nicknamed fish is the tiger-of-the-sea, or barracuda (Color Plate, page 193). The barracuda is a carnivorous pirate from the tropical and sub-tropical regions, and has been recorded as reaching a length of eight feet and a weight slightly exceeding one hundred pounds. It is amazingly swift in action when hungry. It will strike at its prey without hesitation, on sight, darting with lightninglike rapidity at the moving object, big or small, fast or slow.

THE BARRACUDA IS A KILLER

While it is cruising, its movements are slow, and its habit of hiding under floating objects reminds one of a submarine lurking in the steamer lanes ready to strike down a passer-by. The teeth of this fish are most sinister in appearance, having a cutting edge on both sides, which, with the powerful leverage of its mighty jaws, can inflict a terrible wound. It will attack almost any kind of sea denizen, its own species included, no matter what the size, and with one snap it can sever the body of an unbelievably large fish.

This has been demonstrated often to fishermen, who have had their catch cut in two by a barracuda before it could be hauled into the boat. The tiger-of-the-sea is itself a savage fighter when hooked, though it generally gives up after a few minutes of very strenuous action.

Many people fear the barracuda more than the shark, though probably many bites

attributed to them are in reality those of the shark. An experienced person, however, would have no difficulty in distinguishing the two bites, on close observation. The bite of the barracuda is straight and clean while that of the shark is almost invariably crescent shaped and inclined to be a little more jagged.

This ferocious creature, like practically all fish that are kept in captivity, will become docile when properly cared for. At the former Aquarium, which was so admirably located at Miami Beach, Florida, one of the aquarists would pet the barracuda much as a child would stroke the back of a cat, and the fish would, in a seemingly gentle way, take food from his hand.

COMMERCIAL FISHES OF THE WARM SEAS

Not all of the fishes and water fauna of the warm seas are sought after merely as game, however, and a great many of them are caught commercially. The groupers, red snappers, kingfish, and Spanish mackerel are the mainstays of the market fishermen in the waters around Florida.

Of the grouper family, the black grouper (Color Plate, page 196) and jewfish reach the largest size, the latter sometimes weighing as much as 600 pounds. Both of these species are very wary at times and are difficult to catch. Sometimes they will encircle a bait for an hour before taking it. The most effective method in taking the black grouper is by trolling, since this fish is very susceptible to a moving bait.

The Nassau grouper (Color Plate, page 195) is another large member of the family. Like the other groupers, it inhabits the coral reefs and lives a solitary life, except in the breeding season during May and June, when it is gregarious. Hence the name grouper. It changes color with great facility, though the black spot at the base of its tail retains its deep color regardless of the other changes in its body coloration.

Very similar in shape is the red grouper (Color Plate, page 195), though, on the average, it is not so large as the Nassau species, forty pounds being a high weight. It is a good food fish and its color of reddish brown gives it a striking appearance.

Another highly esteemed member of the groupers is the gag (Color Plate, page 196). Not only is it a good food fish but it is a game one, though it seldom attains a length greater than four feet. Its principal habitat



Photograph by John Oliver La Gorce

SWAPPING WHOPPERS

To young and old alike, the mystery and lure of angling is ever beckoning and the teller of fantastic fish stories is always with us.

is along the Florida reefs, though it also frequents the Bermudas.

The gamiest of the grunt family, the Margate fish (Color Plate, page 198), is another fine food fish, as is the muttonfish (Color Plate, page 194) of the snapper family. Twenty pounds would be large for a Margate fish, and twenty-five pounds for the muttonfish.

Some of the species mentioned are popular only locally, but the Spanish mackerel (Color Plate, page 199) is well known in most of the cities throughout the States and Canada. Millions of pounds of these fish are shipped north annually from Florida alone. Key West at one time shipped more than 3,000,000 pounds a year, but with the passing of the railway line between there and Miami and north, the transportation problem cropped up. However, with the new highway these difficulties have been overcome and the little island again flourishes.

KINGFISH AND MACKEREL POPULAR

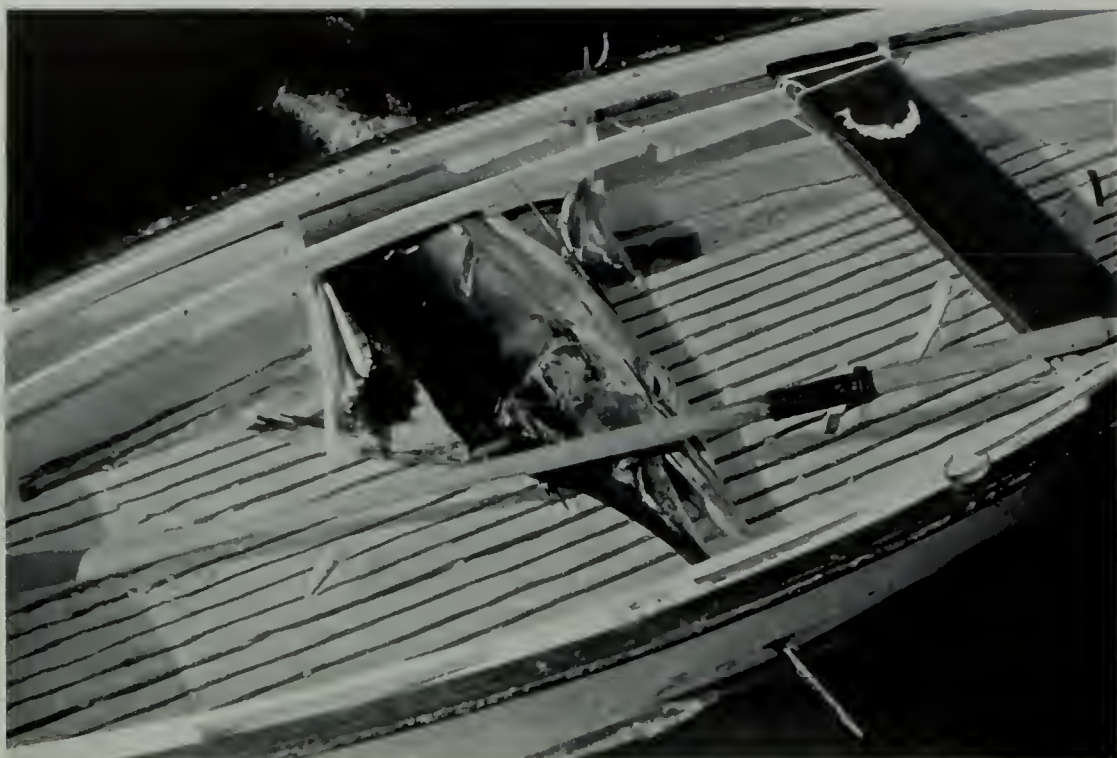
Closely associated with the Spanish mackerel is the kingfish (Color Plate, page 199). Both belong to the same family and are much alike in many respects, though the latter grows considerably larger and

attains a weight in excess of 100 pounds at times. About half as much kingfish as Spanish mackerel is shipped north.

Quite similar to, though much less numerous than the kingfish, is the wahoo or queenfish, or peto, as it is called in Cuba. A larger fish, reaching a weight of 130 pounds, it affords great sport to the angler and even greater delight to the person fortunate enough to have it as food. Wahoos are probably more numerous around Bermuda than anywhere else in the Atlantic, though there are many to be found in the waters off Panama, Cocos Island, and the Galapagos Islands in the Pacific.

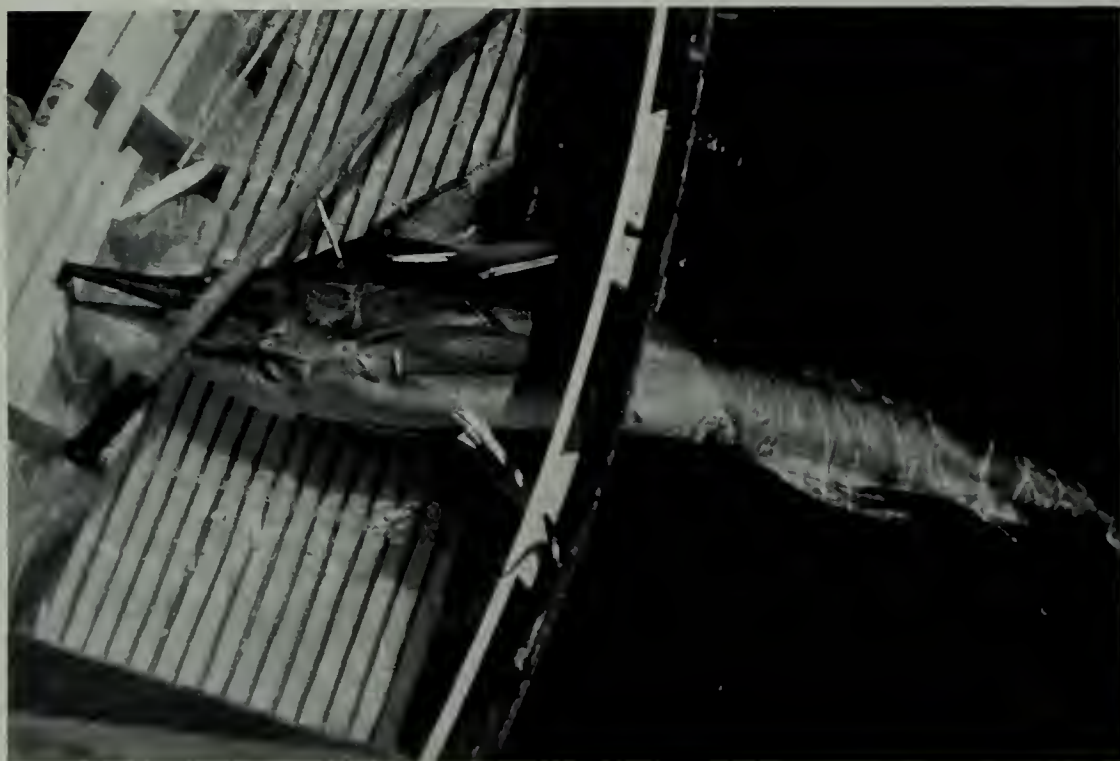
Most of the fishes referred to are carnivorous and are not generally seen in neighboring waters of populated sections. It is by no means a rarity, however, for them to frequent the haunts of man. While wariness is a common trait of game fish, one family, the jacks, seem to have no fear of man and his traffic. They may often be observed resting lazily under a bridge or near the shore where the traffic is constant. They cruise slowly along, awaiting the approach of their favorite food, the mullet, and when the latter appear in large schools there is instant action.

The amberjack or amberfish (Color



THE SWORDFISH PROVES ITSELF A HIGH-POWERED PROJECTILE

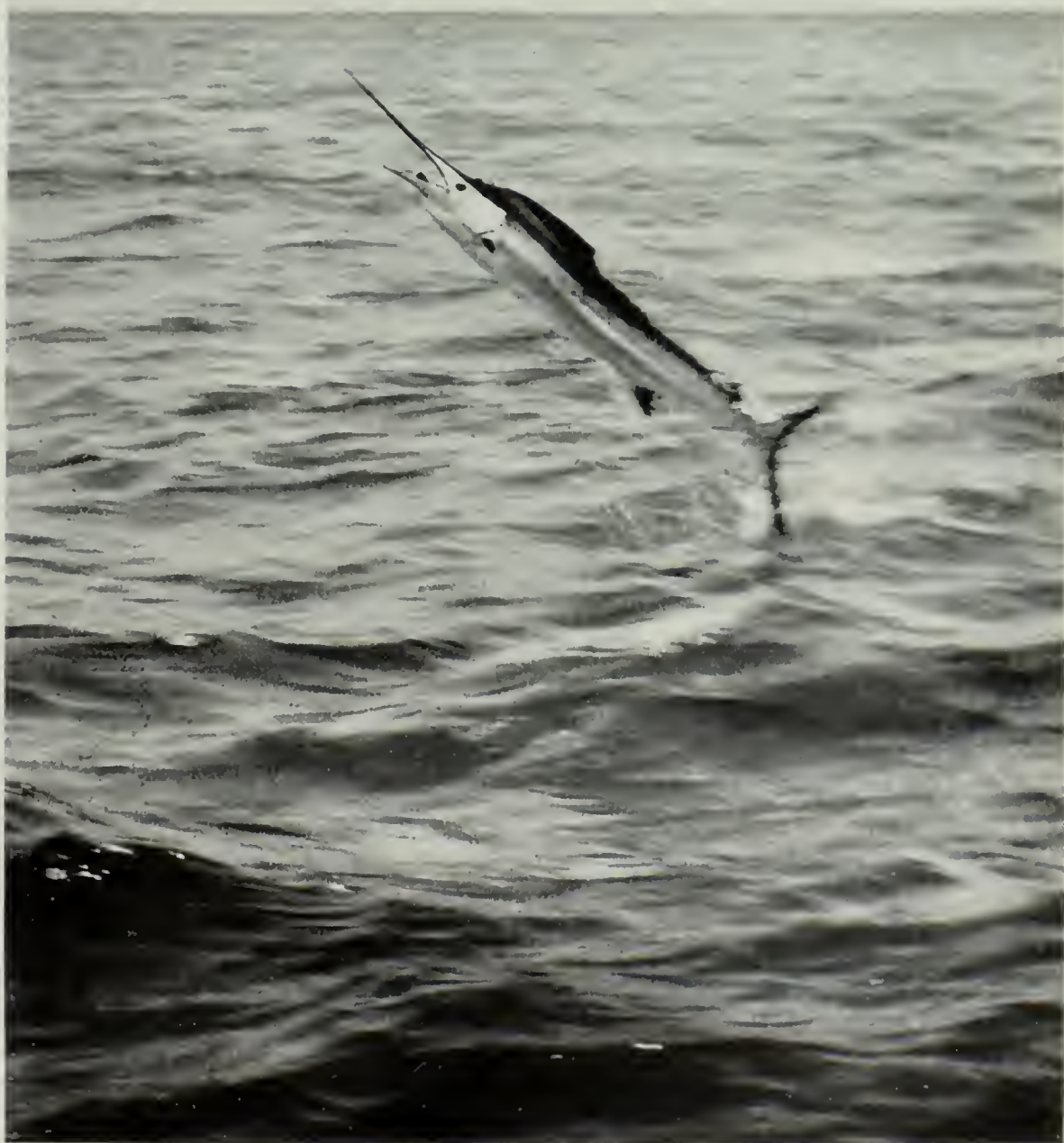
When the crew of the yacht *Sirocco* came into Los Angeles Harbor with a weird tale of a sea monster that had rammed their fishing boat, nobody believed them, but they substantiated their story with photographic evidence.



Photographs by Al Wetzel

WOE TO THE SMALL BOAT RAMMED BY A SWORDFISH

This 240-pounder, "harpooned" by a famous archer's barbed arrow, suddenly turned on the dinghy from which its tormentors had been playing it for two hours. Like a torpedo it crashed through the side of the craft. The fishermen were tossed overboard but unhurt.



© Erl Roman

“TAIL-WALKING”

The speedy sailfish usually hunts its food in the warm seas on or near the surface and is attracted by the fisherman's lure trolled well behind the boat. Nature omitted teeth but provided a spearlike weapon with which it strikes and stuns its prey. When hooked, the sailfish gives instant battle, constantly leaping high out of its natural element, trying to shake the offending steel from its mouth. It appears to be actually walking on its tail for many yards at a time.

Plate, page 205), the largest and gamiest of this family, inhabits both the shoal and deep waters around the Florida Keys, the West Indies, and Bermuda. It provides excellent sport for trollers, and will take almost any kind of live bait offered to it in still-fishing. It is a carnivorous, surface-living fish of considerable food value in the Bermudas and the West Indies, where large numbers are caught for market purposes. It is not so highly considered in the Florida markets, where its cousin, the yellow jack, is more common. Amberjack reach a weight of about 170 pounds. The runner or yellow jack (Color Plate, page 205) is also a surface fish of graceful lines and beautiful coloration. It resembles the amberjack closely, both in habits and appearance, although it does not reach so large a size.

TURTLES PROVIDE FOOD AND SHELL

Reptiles as well as fish have found the Gulf Stream a kindly habitat. The turtles, the most valuable of the reptiles, are diminishing rapidly in many of the localities where they were formerly abundant. Without doubt, the green turtle (Color Plate, page 208) is the finest-flavored of the sea turtles and the most highly esteemed as food. It is an herbivorous feeder, inhabiting the open seas in the West Indies, the Bahamas, Brazil, the Gulf of Mexico, the Pacific Ocean, and the Straits of Florida, although it is now almost extinct in Florida waters. The greatest numbers are taken off the Mosquito Coast of Central America.

The green turtle is a beautiful species, reaching a weight of more than 700 pounds, but averaging considerably less. In captivity it becomes quite tame and thrives on turtle-grass, lettuce, and purslane, or "pusley." It will eat flesh, but is chiefly a vegetable feeder.

There is a danger that these turtles will be wiped out of existence. They are far less numerous than in past seasons, for the natives destroy the eggs. The female turtle visits the beaches from April until June to deposit her eggs. This she does by digging a hole to a depth of from 14 to 18 inches in the sand, where she lays from one to two hundred eggs. On the fourteenth night from the first deposit—on what is known as the second crawl—she returns to lay more eggs close by her first nest.

Not only do the natives of the islands where the turtles crawl rob the nests, but

they frequently catch the turtle after she has deposited her eggs, thus wiping out at one stroke both the mother and all her potential progeny.

Although statutes covering the protection of the turtles are written into the laws where these reptiles were formerly plentiful, the marauders continue their work of despoliation.

Man, although the greatest, is only one of the enemies of the turtle. When the young are hatched, they dig to the surface of the sand and immediately make toward the sea. Their instinct in locating the proper direction is unerring, and freshly hatched turtles, flipped like a coin and turned away from the sea, will wheel around and make directly for the salt water. The pelican and man-o'-war bird swallow the young as soon as they observe the small creatures on their way to the water, and if they reach the water they are harassed by their fellow sea-dwellers.

The hawksbill, or shell turtle, (Color Plate, page 208) is without question the most beautiful of sea turtles. It is the producer of the much valued tortoise shell of commerce. This species is found in considerable numbers in the West Indies, where its members deposit their eggs from May to July. It is also distributed throughout the Gulf of Mexico, south to Brazil and the Straits of Florida, although it is now rare in the last-named section to an even greater extent than the green turtle. Large quantities of the valuable shell are shipped every year, principally to Europe. The flesh is not so highly esteemed as that of the green turtle, but it is eaten in some localities.

"BULLYING" A TURTLE

While the shell turtles are taken principally in large nets, into which they are driven, the natives of the West Indies have another method of catching them, known as "bullying." They drop over a sleeping turtle the "bully," an iron hoop four feet in diameter covered with a net like the crown of a hat. The turtle becomes entangled in the meshes and is then easily brought to the surface.

When alarmed, the turtle will hide its head, much as the ostrich has erroneously been supposed to do, and then considers itself quite safe from observation.

Crustaceans play no mean part in the life of the sea. They cover a wide range



Painting by Masume Murayama

FEARLESS AND ARROW-SWIFT, THE BARRACUDA IS A LURKING "SUBMARINE" OF THE WARM WATERS

Well deserving its nickname of "The Tiger of the Sea," the carnivorous **Barracuda** (*Sphyrna barracuda*) darts at its prey on sight and kills fish many times its own size. Numerous instances are recorded of the barracuda's attacking human beings, and the natives of the West Indies fear it even more than they do the shark. It reaches a length of eight feet or more. It is found in tropical and subtropical waters, from Cape Cod south to Bermuda and Brazil, and is common among the Florida Keys. A close relative is plentiful in California waters.



Painting by Hashime Murayama

GAME FIGHTER OF THE SNAPPER FAMILY IS THE TASTY MUTTONFISH, STAPLE OF WEST INDIAN MARKETS

Living on rocky and grassy bottoms and feeding on small fish and crustaceans, the **Muttonfish** (*Lutianus analis*) attains a weight of 25 pounds. It is an excellent food fish known from Brazil to Florida. It strays as far north as Massachusetts. Quantities are caught among the Florida Keys and off Cuba.



Hashime Murayama

Painted by Hashime Murayama

HANDSOME AND EDBLE HEAVYWEIGHTS ARE THE NASSAU GROUPEE (LOWER), WHICH CAN CHANGE ITS HUE, AND THE RED GROUPEE
Researches of the late William H. Longley proved that the groupers and the muttonfish (opposite plate) feed at night and idle away the day. The Nassau Grouper (*Epinephelus striatus*, lower), ranging throughout the West Indies and from Florida to Brazil, attains a weight of 50 pounds. It takes the hook readily, but is not very gamy. The Red Grouper (*Epinephelus morio*, upper) is found from Virginia to Rio de Janeiro. It averages somewhat smaller than its cousin. Both are solitary wanderers among the coral reefs, except during the breeding season, when they become gregarious.



Hashime Murayama

Painting by Hashime Murayama

WHEN FLORIDA FISHERMEN EXCLAIM, "IT'S A GAG!" THEY ALLUDE TO A FISH, NOT A JOKE

A fine food fish, the **Gag** (*Mycteroperca microlepis*, upper) is one of the commonest groupers. Weighing as much as 40 pounds, it is found among coral reefs along our south Atlantic and Gulf coasts, being abundant among the Florida Keys but rare or absent in the West Indies. A common fish in the Florida Keys and West Indies is the **Black Grouper** (*Mycteroperca bonaci*, lower) which reaches a weight of 50 pounds. Neither of these species has yet attained the commercial importance which it deserves.



Painting by Hashime Murayama

AN IRIDESCENT BEAUTY IS THE "HIGHBROW" OF THE SPANISH MAIN

With its steep forehead and mother-of-pearl sheen, the **Moonfish**, or **Look-down**, (*Scleromorphus*) seems to seek attention as it preens and scrubs itself on the sandy shallows. Highly regarded as a food fish, but not available in commercial quantities, it is found from Maine to Uruguay, and is taken in seines among the Florida Keys. A closely related species frequents Pacific coastal waters.



Painting by Hashime Murayama

THE MARGATE FISH—ONE OF THE LARGEST OF THE GRUNT FAMILY

Reaching a weight of ten pounds, the **Margate Fish** (*Haemulon album*) is of considerable importance in Florida markets. It is found in the Bermudas, Florida Keys, West Indies, and south to Brazil, living on coral and grassy bottoms, and feeding on crustaceans, worms, and mollusks.



Painting by Hashime Murayama

STREAMLINED SPEEDSTERS ARE THE KINGFISH AND SPANISH MACKEREL

A fine table fish, the **Kingfish** (*Scomberomorus regalis*, upper two) may reach a length of three feet and a weight of 50 pounds, although 5 pounds is about the average. It is found from Brazil to Cape Cod. A close relative, smaller and of thicker proportions, is the **Spanish Mackerel** (*Scomberomorus maculatus*, bottom fish). It lives in the warmer seas, appearing in large schools migrating along the Atlantic and Gulf coasts, and is one of the best and most popular of American food fishes. Glistening in metallic splendor, it is found from Cape Ann to Brazil, attaining a weight of about 12 pounds. Both species are game fighters on light tackle.



Hashime Murayama

Painting by Hashime Murayama

GOLD OF SUN AND BLUE-GREEN OF SEA, SPEED OF WIND, AND GRACE OF THE CURLING WAVE

Of all fishes, the **Dolphin** (*Coryphaena hippurus*) is considered the fastest swimmer. In the open sea, it feeds largely on flying fish, which it follows along the surface and captures at the moment of their striking the water. Only the adult male has the characteristic high forehead. One of the gamest of all fish, the dolphin is also esteemed as food. It inhabits warm seas throughout the world, reaching a maximum length of six feet and a weight of 75 to 100 pounds. The "dolphin" of the ancients was a mammal, one of the porpoises.



Painting by Hashime Murauma

HAPPY IS THE SPORTSMAN WHO LANDS A BONEFISH

Wily and wild, the **Bonefish** lives up to its Latin name, *Albula vulpes*—"whitish fox." On light tackle, this frequenter of all warm seas is one of the most tireless fighters of fishdom. Hermit crabs, crustaceans, and worms are the favorite food. Among the Bahamas and the Florida Keys, it frequents shallow, sandy areas, reaching a maximum weight of about 14 pounds. While young, the bonefish goes through a larval stage in which it is a flat transparent, ribbonlike creature.



Painting by Hashime Murayama

THE BAITLING "SILVER KING" IS ACCLAIMED THROUGHOUT THE WORLD OF SPORT FISHING

As the **Tarpon** (*Tarpon atlanticus*) dashes about and leaps from the water, trying to shake free from the hook, its large scales glisten in the sunlight like molten silver. The tarpon reaches a length of more than eight feet, and weights in excess of 200 pounds are recorded. Epicures do not relish its dry, coarse flesh, but it is popular as food among the Central American Indians. It is known chiefly from the Florida Keys and the Gulf Coast, but ranges, well offshore, from Long Island to the West Indies and Brazil. On both Florida coasts it frequents, in considerable numbers, passes between reefs and islands, estuaries, and river mouths, and in early years even enters fresh and brackish water in some localities. Like the bonefish, the tarpon passes through a larval stage when young.



Painting by Hashime Murayama

OUT OF WATER OFTEN RISES THE BROAD DORSAL FIN WHICH SUGGESTED THE MIGHTY SAILFISH'S NAME

The **Atlantic Sailfish** (*Istiophorus americanus*) is prized among anglers not only for its supreme courage as a fighter, but also because it makes a splendid mounted trophy. This fish inhabits warm seas and is common about the Florida Keys, where it reaches a length of more than six feet and a weight of 120 pounds. It is an excellent, but not commercially abundant, food fish.



Painting by Hashime Murayama

SPINY LOBSTERS KEEP AN UNDERSEA RENDEZVOUS

A shellfish of great importance, the **Crayfish**, or **Spiny Lobster**, (*Pandalirus argus*) has delicately flavored flesh which is highly esteemed as food. It also provides excellent bait, being eagerly taken by most fish. It sometimes attains a body length of 18 inches, but averages ten inches. The female (left) has a small pinching claw on the last leg, which is used to comb the eggs and free them from foreign substances, as well as to remove the dead eggs. A very valuable market species, the spiny lobster is taken in commercial quantities in the West Indies, the Bermudas, and the Florida Keys.

Hashime Murayama



Painting by Hashime Murayama

SHAPELY FAVORITES OF SOUTHERN SEAS

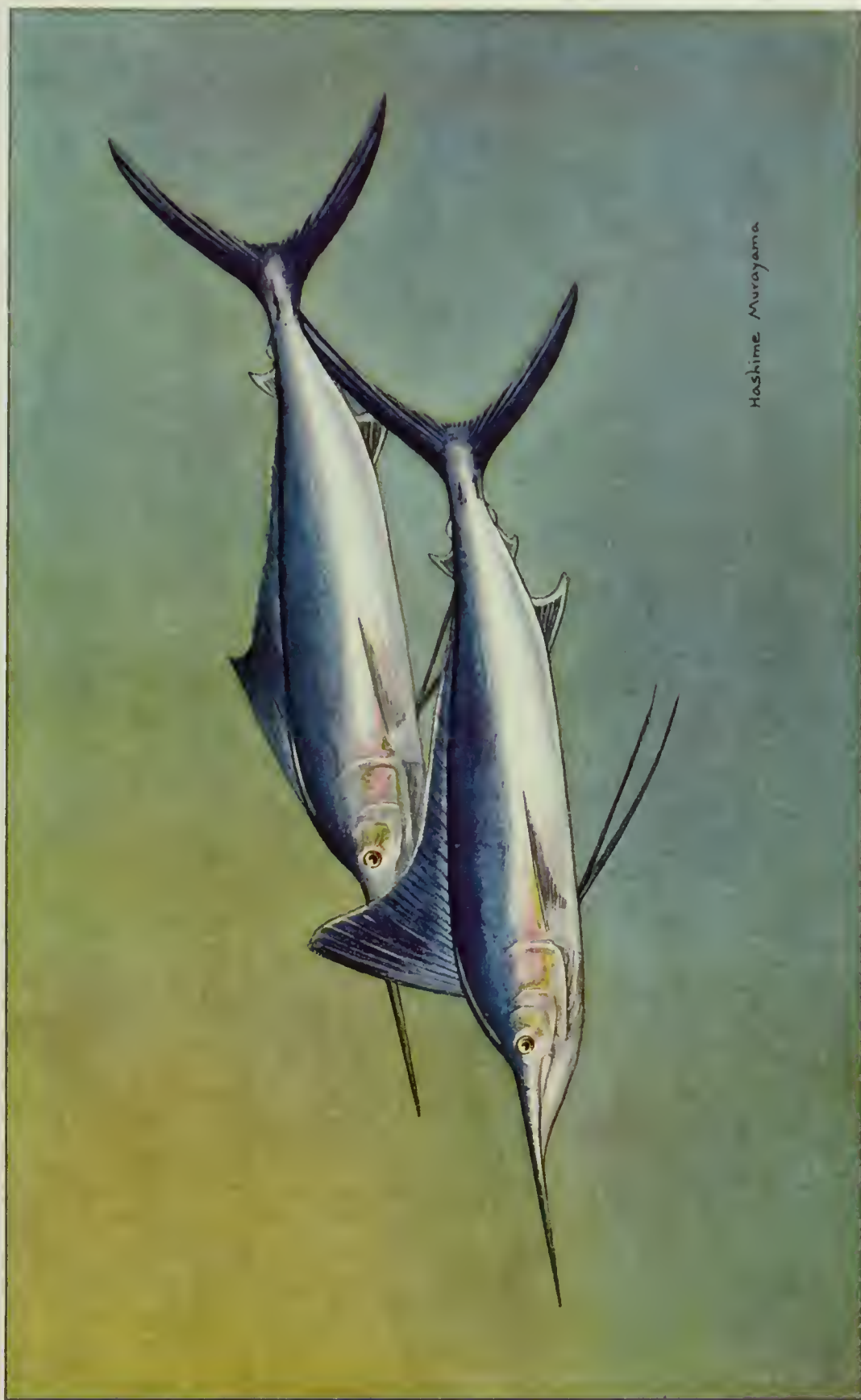
With little fear of man's presence or his works, the **Amberjack** (*Seriola dumerili*, upper) likes to hide about old wreckage as it lies in wait for schools of mullet, its favorite food. It is found from the Bermudas and Carolinas to Florida, the West Indies, and Brazil, attaining a length of five or six feet. A much smaller fish is the **Runner** (*Caranx ruber*, lower) which inhabits the open waters, bays, and inlets from the Carolinas to the West Indies. Both are gamy fighters, taking the hook readily.



Painting by Hashime Murayama

OUT OF THE GROTESQUE APPEARANCE OF THE OCTOPUS HAVE GROWN "TALL STORIES" OF ITS VICIOUSNESS

A familiar figure of sea fiction and romance, the weird-looking **Octopus** (*Octopus americanus*) is a repulsive creature, with its big, ugly head and gaping mouth armed with powerful horny jaws similar to a parrot's beak. Close-set eyes send forth a demoniac glare. The fantastic head is mounted on an oval body from which radiate eight arms provided with suckers. Large octopuses have been known to spread their limbs 14 feet



Hashime Murayama

Painting by Hashime Murayama

AMONG BIG GAME OF THE SEA, THE MARLIN HOLDS A PLACE OF HONOR

Closely related to the sailfish, the **Marlin**, or **Spearfish**, (*Makaira amplia*) is easily distinguished from the former by its low dorsal fin. It is one of the very gamest of salt water denizens, being noted for its amazing leaps, and is also a fine food species. The marlin reaches a length of 12 feet and a weight of more than 600 pounds. It is found in the warmer parts of our Atlantic waters. Recently, Ocean City, Maryland, has become prominent as a new center for rod-and-line angling for this magnificent fish.



Painting by Hashime Murayama

ONE PROVIDES TORTOISE SHELL; THE FLESH OF THE OTHER IS THE FINEST-FLAVORED AMONG THE TURTLES

The **Hawksbill Turtle** (*Eretmochelys imbricata*, left) furnishes the ornamental tortoise shell, which is shipped in quantities from the West Indies annually. This species has an average weight of 30 to 40 pounds, but 200-pound specimens have been taken. The hawksbill lives on fish, crustaceans, and mollusks, among coral reefs from Bermuda to Brazil. The **Green Turtle** (*Chelonia mydas*, right) is the most highly prized of all turtles for food. It attains a weight of 700 pounds, but has an average heft of 50 pounds. It is herbivorous, feeding on marine plants, and is found in tropical and semi-tropical seas throughout the world.

in size, from the most minute of creatures to the great Japanese crab of the western Pacific, whose claws have a spread of 15 or 16 feet.

High in the rank of the American crustaceans stands the crayfish or spiny lobster (*Panulirus argus*) of southern salt waters (Color Plate, page 204). It is smaller but, some think, of even a more delicate flavor than its northern cousin (*Homarus americanus*). This species should not be confounded with the fresh-water crawfish, an entirely different form.

The *Panulirus argus*, or spiny or southern lobster, is one of the largest of the crustaceans known to inhabit the Atlantic, the Mediterranean, and Caribbean seas and is generally conceded to be the most toothsome. It appears in a place of honor on seafood menus in the finest restaurants.

The crayfish provides an abundance of food material. Large numbers are shipped every year from the Florida markets. It dwells among the coral reefs and leads and is usually caught in traps baited with small fish, although "bullying" and spearing are also practised to some extent.

THE SOUTHERN LOBSTER IS TOOTHsome

The crayfish is not only a delicacy for human consumption but is relished, too, by the inhabitants of the sea and is an excellent bait for most fish in the Florida waters. Even the most decidedly herbivorous fishes eat, and appear to relish, the fine white flesh of the crayfish.

Crayfish are easily kept in an aquarium and make an interesting exhibit. This is particularly true of the female during the spawning season, when she is busy, almost constantly, combing her eggs in her efforts to give her prospective progeny a fair start in the arduous life into which they are about to enter. The color plate shows a specimen carrying her eggs. On the last leg may be noted a pincer, which is used in removing the dead eggs and debris which may adhere to the egg clusters.

Florida, like a great sunlit spear thrusting down toward the Caribbean, is favored by Nature in many ways. Particularly is this true in the treasure of marine life that abounds on both its coasts and in its myriad inland fresh-water lakes and streams, teeming with fish.

Each year the State welcomes increasing armies of visitors numbering tens of thousands, coming from many States and

from every walk of life to enjoy the out-of-doors life that the health-giving climate, warmed by the Gulf Stream and sunshine, makes possible.

A heavy proportion of these visiting men-folk are fishermen by instinct but, manlike perhaps, will not admit to the family that their willingness to make the long journey from the North or Midwest is but answering the silent call to the fisherman's "happy hunting grounds."

FLORIDA A FISHERMAN'S PARADISE

Few other areas in the world can boast of so many places to fish successfully or to find such a variety of species as Florida, with the warm waters of the Atlantic on the east, the sun-drenched Gulf of Mexico on the west, and the streams and lakes of the fresh-water fighters between. Fleets of boats are obtainable at rentals to suit any pocketbook. These craft range from the speedy, especially designed and equipped fishing cruisers at \$25 a day to the humble rowboat at fifty cents.

A number of the cities and towns on both coasts provide excellent public fishing piers for visitors who just want to "shore fish;" and also there are available excursion fishing boats, which daily take crowds offshore to good fishing grounds at a dollar a head, bait thrown in—but give no guarantee against seasickness!

For black bass fishing, the lakes and clear drainage canals of Florida, such as Lake Kissimmee near Miami, Lake Okeechobee, and Lake Apopka not far distant from Orlando, are unexcelled. Indeed, within 25 miles of Orlando can be found a hundred or more good bass lakes.

So it is that every fisherman has his chance in Florida—if he can get there.

Ages before Izaak Walton wrote of the fascination of catching fish only large enough to bob a tiny cork, the lure exerted by the finny tribe for sport-loving men had been conceded. And what real boyhood fun is the sport of angling for sunfish or shiners with a willow shoot for a rod, grocer's string for a line, a bent pin for a hook, and angle-worms for bait!

When the hooking of small fresh-water creatures can bring such joys, is it any wonder that humble citizen and President alike grow enthusiastic over battles royal with rod and reel in which they match their skill, strength, and endurance with the great creatures of the Gulf Stream?



Photograph by A. W. and Julian A. Dimock

WHAT GOES UP MUST COME DOWN!

This remarkable photograph shows the masterly fight put up by a hundred-pound tarpon. If the mighty fish should land, as sometimes happens, in the small skiff, the fishermen would be in for more excitement than they sought.



Photograph from Van Campen Heijner

LIKE A WINDMILL ON A STRING, THE FIGHTING TARPON WHIRLS IN MID-AIR

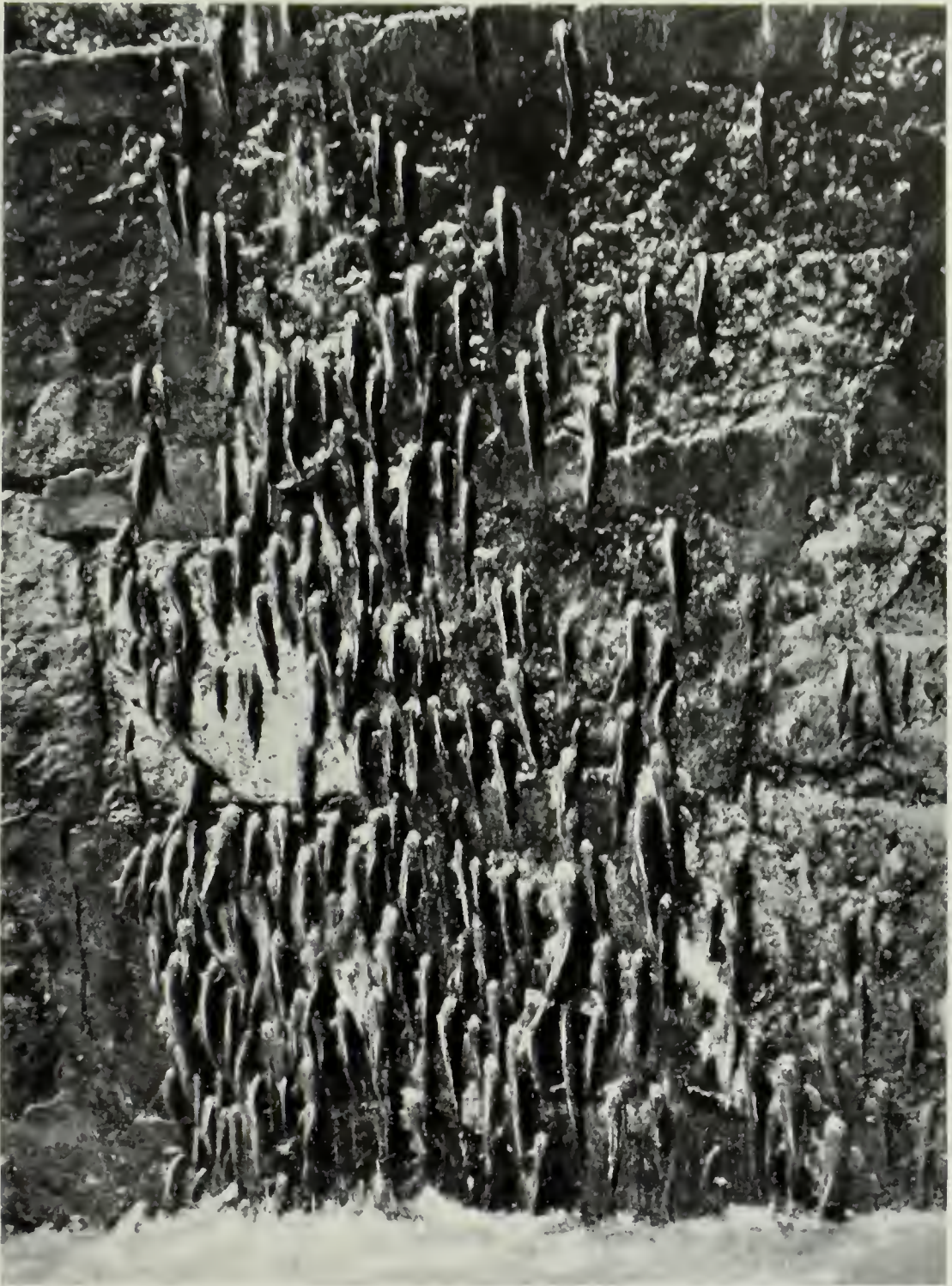
Until the powerful fish is tired out it is capable of jumping over low-hanging branches projecting from the shore and thus freeing itself of the hook.



Photograph by Norman W. Caldwell

SCOURGE OF WHALES IS THE THRESHER SHARK

Equipped with a disproportionately long tail which gives it wonderful pace and extraordinary maneuverability, the creature plays havoc with the mammoth of the deep. Whalers regard it as a special friend, for it frequently locates their prey for them. This shark invades schools of smaller fish, and uses its long tail to splash the surface of the water as it swims about them. By such tactics it keeps the victims crowded together where they may be more easily attacked.



Photograph by Illustrations Bureau, Illustrated London News

AS IF EQUIPPED WITH ARMS AND LEGS, FISH SCALE A SEVEN-FOOT WALL

A species of catfish in India is here shown climbing from the Jumna River using pectoral and pelvic fins. These catfish are also provided with a special thoracic sucking apparatus which enables them to cling to walls or to stones in mountain streams. The Jumna is the chief tributary of the Upper Ganges. It supplies the waters for the irrigation works of the East and West Jumna Canals, which, between them, water almost half a million acres in northern India.



Photograph by Herbert R. Duckwald

WHAT A RED RIDING HOOD TALE COULD FISH TELL OF THE GREAT WOLF OF THE SEA!

The ferocity of the killer whales strikes terror to the other warm-blooded animals of the deep. They are known to swallow small seals and porpoises entire, and they attack large whales by tearing away their lips and tongues. When assaulting large prey, they work in packs. This specimen was captured by Capt. Charles H. Thompson in the Gulf Stream between Miami Beach and the Bahama Islands.



Photograph from Miami Aquarium

ON THE OCEAN FLOOR QUEER CREATURES ENACT A SCENE MORE FANTASTIC THAN THE DREAM OF ALICE IN WONDERLAND

Giant anemones very much alive, though they look like white chrysanthemums, constantly move their long petals in search of minute particles of food. The clusters of black "hatpins" are living sea urchins so protected by their movable quills that few marine animals disturb them. The hermit crab walks about with his borrowed home, an empty conch shell, and the starfish is much in evidence. The beautiful tinted sea-fan forming a background for a long-spined sea urchin is thriving in a cluster of coral.



Photograph by Richard B. Hoit

UNUSUAL FOR A SAILFISH IS A LEAP WITH ITS BIG DORSAL FIN SPREAD



Photograph from David and Michael Mahoney

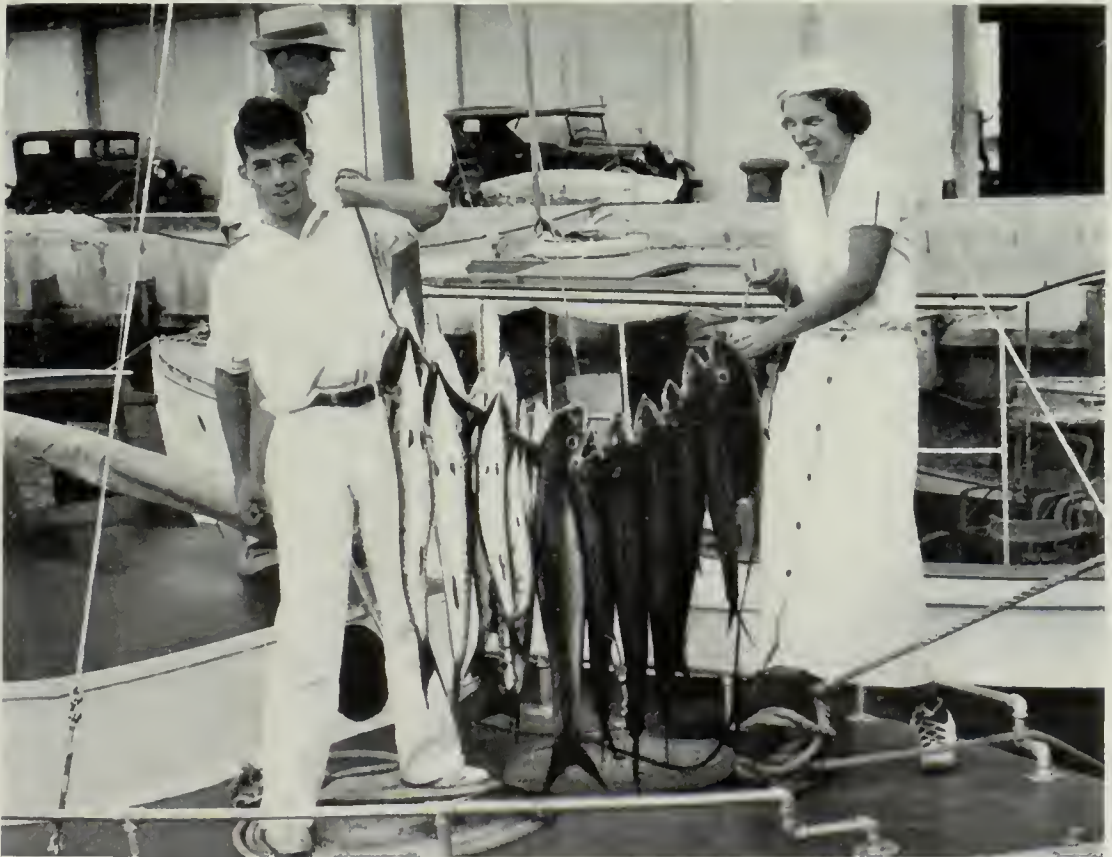
TROPHIES FOR THE CLUBHOUSE WALLS

Had they not been desired for decorations, these sailfish caught off Miami Beach would have been released. The youngsters have since won their own spurs as sailfishermen.



© Venice Tarpon Club

THERE'S MANY A SLIP BETWEEN A TARPON'S STRIKE AND ITS FINAL CAPTURE



Photograph by Gilbert Grosvenor

SHARKS OR BARRACUDAS OFTEN BITE A FISH IN HALF BEFORE IT CAN BE LANDED
The specimen at the right in this fine catch suffered such a fate. Barracudas are voracious, fast-swimming fish, common in Florida waters and many other warm seas.



Photograph by John Degelman

WITH STURDY POLES, FISHERMEN JERK TUNA OUT OF THE PACIFIC

Boiling white patches on the sea mark where the hungry fish seize sardines and other live bait showered out to them by the chummer. After coaxing the big fighters alongside the fishing vessel, the men work fast to pull in all they can before the school moves away. Hooks are disguised by bits of chicken feather wrapped around with dry fish skin to protect them from the teeth of the prey. Sometimes an hour's take amounts to several tons. This big catch was made near Jicarón Island outside the Gulf of Panama.

TREASURES OF THE PACIFIC

Marine Fishes and Fisheries Yield Vast Wealth from Alaska to Baja California

BY LEONARD P. SCHULTZ

Curator of Fishes, United States National Museum

MARINE fishes and fisheries form the basis of one of the most important industries of the west coast of the United States. In our Pacific ports a larger poundage of fish is landed than in our Atlantic and Gulf coast ports combined.

Monterey, California, in poundage, is the third largest port of entry for fish in the world, exceeded only by Hull, England, and Stavanger, Norway; and Los Angeles-Long Beach is fourth. These and many other interesting facts about the marine fishes and fisheries of the West came to my attention in the years I was teaching fisheries courses at the University of Washington, and collecting fishes from Washington to California.

THE SEA SERPENT MYTH

Sea serpents are known the world over, mostly from newspaper accounts of these mythical monsters. From British Columbia comes the story of a long-haired "sea serpent" found on the beach. Alas for romance! The hairs were the long gill rakers of a mammoth basking shark, which had become stranded and then partly decomposed.

Sea serpents are figments of imagination, created from glimpses of huge fish, or compact schools of small fish swimming near the surface of the ocean. In the Pacific the "king of the herring," a long, harmless, ribbon-shaped fish with a high dorsal fin in front, the reddish tips of which often extend out of the water when it is swimming near the surface, is good material for such a yarn.

Other myths of my childhood were shattered when I took up the serious study of fish. For instance, when I used to angle for sunfish in a small lake in Michigan, my elders cautioned me not to talk loudly lest I frighten the fish away.

I have learned since that sound in air is not transmitted to water except slightly, but that the stomping of feet in the bottom of the boat causes vibrations that can be heard in the water. Well do I remember

as a boy swimming beneath the surface how two stones struck together in the water caused a frightful noise in my ears.

Experiments in firing guns over lakes have shown that the terrific sound in the air is barely heard by a diver under the surface. Although fishermen of the high seas have placed emphasis on the disappearance of fish as a result of gunfire from battleships, no signs of frightened fish have been discovered in the surrounding waters during repeated firing of large and small naval guns over stretches of many miles.

The firing of big guns does not kill fish, but dynamite explosions in the water do. Once while I was at Yaquina Bay, Oregon, with Dr. Carl L. Hubbs of the University of Michigan, the Government was blasting the channel deeper. We were anxious to collect the fish killed by the detonation of a ton of dynamite that shot a column of water several hundred feet in the air.

Although we were a quarter of a mile away, the force of the explosion stung the bottoms of our feet in a rowboat. The terrific noise from the first explosion was the signal for thousands of sea gulls and other aquatic birds to come and eat the dead and stunned fish that floated to the surface. Before we could pick up a fish, the birds had consumed them all.

BIRDS WATER-BOUND FROM OVEREATING

Soon we discovered they had eaten so many fish that some could not fly from the water. We caught several birds and made them disgorge the fish in the bottom of the boat. In an hour we had a fine collection; the fish were not damaged by their short stay in the stomachs of the birds.

From additional experiences and explorations by students of fish, some of which date as far back as 1731, many of the mysteries associated with the life story of fishes have been discovered. By the use of dredges and trawls the deep-sea fish fauna of the Pacific has been explored to considerable extent, and strange and almost incredible forms have been revealed.

Certain shore fishes, especially those small finny creatures inhabiting the reefs and rocky shores of our west coast, are no less interesting for their tiny size. Many of the tide pool species occupy a special niche in the habitat and seldom stray far away. I have taken at least three species of blenny, elongate eel-like fishes, by digging up the black mussel beds on the reefs at Cape Johnson on the outer coast of Washington. The blennies living among these mussels are usually black, but those living in the green eel grass are green.

In the rock pools lined with brilliantly colored coralline algae, the fishes, mostly sculpins, are variously red, pink, blue, and yellowish.

At moderate depths the fishes are bright red, with large eyes. The soft-bodied fish, living still deeper, have large eyes also, to catch the faint glimmerings of light which penetrate to that depth, or they are entirely blind. Those from depths of half a mile or so are usually black.

WONDERS OF THE DEEP

Many of these deep-sea fish, as well as those near the surface, such as the lantern fishes and the singing fish, have luminiferous organs along their sides and on their heads that give off light like a firefly at night. These many luminiferous organs on the singing fish, or midshipmen, look like the pearl buttons of a uniform when the fish is taken from the water. Hence the name "midshipmen." The name "singing fish" is appropriate, too, for the creatures produce a peculiar humming sound during the breeding season.

Certain deep-sea angler fishes have one of the fin rays near the top of the head developed into baitlike tentacles with a luminiferous gland, or "electric light" at its very tip. There has been much speculation on the use of this most delicate and unusual organ, some students thinking that it serves as "bait" to attract live food, and others that it is a courting spark to beckon a mate in the total darkness of the depths of the ocean.

Other remarkable structures are found on fish. For example, the rock snails and clingfishes are provided with sucking disks, just back of the lower parts of their heads on the underside. This hydraulic sucking organ enables them to cling to objects securely while the waves and tidal current rush past. At intervals of quiet between

the passing of the waves they swim about, obtain food, and then fasten themselves again to a rock to avoid being swept away by the next wave.

These structures are no more wonderful than the breeding habits of the grunion, the surf smelt, and many other fishes. On moonlit nights during the high tides of March to June, the grunion comes in on the long sandy beaches of southern California with the sweep of the water up the beach as the waves break, lies for a moment, then flips back into the wash of the next wave, having deposited its eggs, fertilized the instant they are laid, in the sand of the beach. Succeeding tides bury the eggs deeper, protecting them until the next series of high tides washes them out to sea two weeks later.

GRUNION SPAWN BY MOON TIME

Shortly after the tide begins to recede, the spawning grunion appear in this tidal series on the second, third, and fourth nights after the full moon. Two weeks later the eggs laid are ready to hatch, and at this time another series of high tides accompanying the new moon washes them out of the sand, causing them to hatch.

Experiments have shown that grunion eggs can be kept in moist sand, and after two weeks made to hatch at any time by the simple expedient of adding sea water and releasing them from the sand by stirring. The grunion depends wholly on the constancy of the tidal cycles, first to help bury the eggs, and then to release them from the sand. The tides accompanying the new moon, when the eggs are ready to hatch, are higher than the usual tides, as are those accompanying the full moon.

The surf smelt, or silver smelt, deposits its eggs along the shore only in fine gravel as the ocean wave breaks and flows up the beach. The eggs are laid and fertilized the second or so that the fish are in the upper part of the wave and they stick firmly to the gravel. Thus, even though subsequent waves roll them around violently, they do not become dislodged.

The selection of fine gravel instead of sand by the silver smelt is a remarkable adaptation. In sand the eggs would be buried and might smother, but in fine gravel the easy seepage of sea water assures the eggs ample oxygen for their development.

Sportsmen and tourists capture these surf smelt on the spawning grounds in a



Photograph by Pix

FISH SWIM TO DEATH IN THE BAJA CALIFORNIA DESERT TEN MILES FROM THE SEA

Sometimes on the road between Tiajuana and Mexicali, thousands of dead fish can be seen, piled in enormous mounds under the torrid sun. These finny victims of disaster are carried by a tidal wave from the Gulf of California over the shores and far inland. When the wave recedes, tens of thousands of them are left marooned in the shallow water, which soon evaporates, leaving them to die. Farmers collect the dead fish for use as fertilizer for their land.

few inches of water by dipping them up with hand nets of a special type. Just off the Olympic Highway, in the State of Washington, I have seen men run forward with dip nets into the breaking wave, scooping up many smelt just as they started up the beach to lay their eggs.

In Puget Sound "rakes" of a special type are used to draw the fish from the shallow water. Commercial fishermen detect the schools of surf smelt by their "flipping" just offshore. Nets are laid out quickly around the schools and hauled ashore.

Other fishes build nests. For example, the crested blenny, a common eel-like fish, lays a neat little ball of eggs under and between stones alongshore during late winter and early spring. The male usually stays curled around the eggs to help protect them from molestation until they are hatched. Yellowish eggs of the clingfish are laid also on the undersides of stones.

Although most fish eggs, or roe, are edible, the eggs of sculpins are often poisonous if eaten. Such eggs are found among rocks and on pilings, as well as between clusters of the blackish mussel that grows on pilings and on reefs exposed at low tide.

HALIBUT EGGS FLOAT IN THE OPEN SEA

The halibut spawns its eggs in the open sea, where they float pelagically. Vast numbers are produced to offset the dangers which overtake the eggs and young fish during their four or five months of helpless drifting. Myriads of them must be swept farther out to sea and lost, because they never reach the banks or sea bottom upon which they can continue their development.

As they grow, the eye on one side migrates, so that both eyes are on the same, or colored, side of the head. Shortly after this, they rise into the upper layers of the water in the ocean and are deposited inshore, along the coast, where their further growth is possible. Maturity is reached in their twelfth year, when they are taken by fishermen on submerged offshore banks.

It has been said of old that oceanic fisheries are inexhaustible; that the stock of fish will be replaced by the "fairy godmother" who looks after such things. But experience has shown that the resources of the sea can be used up just as certainly as an oil well can be pumped out.

Fortunately, just before the Pacific halibut became so depleted that it no longer was profitable to fish for them, the United

States and Canada ratified the Northern Pacific Halibut Treaty, October 21, 1924, and there was started an outstanding attempt to conserve and rebuild a marine fishery. This treaty was placed in the hands of an international commission to obtain facts, and in 1931 the commission was given powers of regulation.

The method of fishing for halibut is to lower on the sea floor a long ground line to which are tied, every nine or thirteen feet, lines five feet long with hooks attached. The distance between the lines is determined by convenience of handling on the deck of the fishing vessel.

The ground line is 1,800 to 2,100 feet long and is known as a "skate." From four to twenty skates may be spliced together and set. Every halibut gear is anchored at each end with buoy kegs and flag markers to indicate its position.

The Indians used similar methods and developed a hook more efficient than our present fishhooks. It was not suitable, however, for use in such large numbers as is necessary in the present type of commercial fisheries.

In 1907 the stock of halibut south of Cape Spencer, Alaska, must have been much greater than now, for that year the halibut fishermen were catching an average of 280 pounds to every 6-line skate fished. By the end of the war in 1919, only 82 pounds were landed with the same gear and in the same fishing time. The catch fell to a low of 35 pounds in 1930, a year before the halibut commission put into effect its regulatory measures.

Today the stock of halibut has recuperated and increased until in 1937 the fishermen were catching 61 pounds to the skate. Thus was first demonstrated how a marine fishery could be controlled for the benefit of the fishermen. They catch almost twice as many fish with the same effort; or they can fill their boats in practically half the time and with less expense.

NEW METHODS OF TAGGING FISH

Similar studies on other commercially important species are being made along our coast, especially those concerned with sardines, herring, mackerel, and the tunnies.

Noteworthy are the methods of tagging herring. The metal tags are inserted into the body cavity of herring by means of a tagging-gun. This automatic device has a grooved knife as the "barrel," and by means



Photograph by Morhardt and Begnard, courtesy Zane Grey

FROLICSOME LEAPS OF THE MARLIN TURN TO SAVAGE PLUNGES WHEN IT IS HOOKED

This spectacular fighter, the "acrobat of the sea," puts to test the angler's skill from the moment it takes the bait until it is gaffed. Once hooked, the fish may tear off a thousand feet of line. It jumps, walks on its tail, leaps out of the water, and sounds, always fighting to the last, sometimes for more than an hour. Improperly called a "swordfish," the marlin gets its name from the resemblance of its snout to a marlinspike.

of a spring tags are "shot" into the body cavity of the herring. After a hundred tags are used, the device must be reloaded.

Recovery of the tags from the herring is by means of a tag detector, consisting of an induction coil held in a delicate electrical balance with a second identical coil a short distance away. These coils are placed around a chute or conveyer through which the herring pass. As a tag passes the coils, its disturbance of the electrical field causes the opening of a trap door through which the fish with the tag is recovered.

From these numbered tags the migrations or wanderings of herring can be deduced.

FLOATS FROM ACROSS THE OCEAN

Halibut and salmon fishermen, travelers, and others who have been along our west coast, mostly north of Washington State to southeastern Alaska, have noticed, and picked up, on the beach each year, thousands of glass balls. These are net floats used by Japanese fishermen instead of the cork or cedar floats used in America. Some are ball-shaped, others spindle-shaped. A

few are as large as 18 inches in diameter, but most of them are only three to six inches.

"What is the source of these floats?" many ask. Some believe they come from the nets used by Japanese fishermen operating in the Gulf of Alaska and in Bering Sea. However, the United States Coast and Geodetic Survey and the International Fisheries Commission have shown that such floats would be carried by the ocean currents to the Aleutian Islands if released in the Gulf of Alaska. Furthermore, no fishery off the west coast of North America, not even the highly contested Japanese fishery in Bering Sea, uses so many floats as are cast on the shores of British Columbia and southeastern Alaska.

The glass floats have been traced from northern Japan to the Kamchatka Peninsula, where there are extensive fisheries using just such floats. They probably drift across the Pacific Ocean in a little more than a year, carried here by the easterly open-ocean current known to us as the Japan Current and to the Japanese as "Kuroshio."

Northern Anchovy

(*Engraulis mordax*)

Usual Length, 5 Inches

The northern anchovy, family Engraulidae, is found only from British Columbia to Baja California. Its nearest relatives are the herrings, but it differs from them in the size and shape of its mouth, which because of an exceedingly long lower jaw opens to the very rear of the head. With such a mouth and weak teeth, it cannot feed on other fish, and is obliged to subsist on tiny animals and plants (plankton) that float in the sea. Because of this oddly shaped mouth anchovies are recognizable at a glance and are known from seas bordering Europe, Japan, Australia, and North and South America.

These delicate fish, although the largest of the anchovies, are only four to seven inches in length, and are much more important as food for game and food fishes than as prey for commercial fishermen. At certain times salmon, as stomach contents prove, feed exclusively on the northern anchovy off the coast of Washington. I have found the remains of Clupeoids in the stomachs of fur seals and no doubt some of these were anchovies and sardines. They occur in large schools, and about 300,000 pounds of them are netted annually.

The developing eggs of the northern anchovy are found floating freely in the waters of Monterey Bay, California, throughout the year, but most of the spawning occurs from December to June. In Grays Harbor, Washington, recently hatched anchovies have been found in summer.

The eggs are not like the typical spherical fish egg but are about twice as long as wide. Colorless, and almost completely transparent in the sea water, they float at the mercy of the wind and tidal currents.

Pacific Mackerel

(*Pneumatophorus diego*)

Usual Length, 15 Inches

The Pacific mackerel belongs to the family Scombridae and is a close relative of the tuna and albacore of the family Thunnidae. It differs from the latter in having only two small keels on each side of the tail instead of three. The middle one of the tuna is the largest.

It is similar to the chub mackerel of the Atlantic, but unlike the common mackerel in several ways. On the Pacific coast, where it is called greenback mackerel, stripe or zebra mackerel, and night mackerel, it occurs from Prince William Sound, Alaska, southward to California. Other chub mackerels are found off South America and Japan.

The Pacific mackerel spawns from near San Pedro to Cape San Lucas, from April to August. The eggs, floating freely in the ocean offshore, hatch in about three days.

Although the fish averages only about two pounds, one measuring $22\frac{1}{4}$ inches in length

and weighing $3\frac{1}{2}$ pounds has been recorded. The catch off California from 1928 to 1931 ranged from 15 million to 60 million pounds annually, but from 1933 to 1937 the catch varied from 60 million to more than 146 million pounds.

A large proportion of this catch is sold on the fresh-fish market. Recognizing its commercial importance, the California State Fisheries Laboratory has carried on extensive studies of the species.

The fish are taken largely in ring nets and purse seines. Some boats fishing with hook and line on short poles use live bait or feather lures. More important is the set line, usually some 1,250 feet long, with short snells attached every two and one-half to three feet, each bearing a hook. Four or five such lines are carried on each boat, and several weighted buoys with red flags attached are used to float them at the proper depths, the flags marking the location.

The Pacific mackerel is known by anglers for its splendid fighting qualities, but because of its abundance and small size it is not sought by big game fishermen when larger species are available. Fishing is done just beyond the kelp beds in open water in the early morning, because the mackerel are closer to the surface at sunrise than at any other time. They occur deeper in cold than in warm weather, the depth varying from 30 to 75 feet.

They have voracious and indiscriminating appetites, eating anything they can swallow and taking live bait, clams, pileworms, cut bait, and artificial lures.

Yellowtail

(*Seriola dorsalis*)

Usual Length, 30 Inches

The yellowtail, also known as amberjack and white salmon, belongs to the group of mackerel-like fishes called pompano (pompano), or cavalla, family Carangidae, with numerous cousins in practically all the warm and temperate seas.

It is a graceful swimmer, occurring in schools along the shores of the mainland and around the adjoining islands from Monterey Bay, California, southward to the Gulf of California, beyond which it is not common. During the spring and early summer it is abundant off southern California and, later in the season, off Mexico.

It is classed as both a food and a game fish. In recent years from two to four million pounds have been taken annually by commercial fishermen. Many also are caught by anglers, since it is one of the finest of the Pacific game fishes, striking viciously and running fast.

The average weight is ten or twelve pounds, and the largest weight recorded by the Tuna Club is $60\frac{1}{2}$ pounds. The yellowtail feeds on the smaller fishes such as sardines, anchovies, silversides, and shrimps.



Painting by Hashime Murayama

ONE OF THE GAMIEST DENIZENS OF THE SEA IS THE CALIFORNIA YELLOWTAIL (CENTER)

A feather, a spoon, live bait or even a piece of pork rind may lure the highly temperamental **Yellowtail**. Valued as food are the **Pacific Mackerel** (lower), related to the Atlantic's chub mackerel. **Northern Anchovies** (above), small, with large, underslung mouths, are food for larger fishes, but they should not be confused with the European species of hors d'oeuvre fame. Many weeks of intensive study in California preceded the studio work of the artist Hashime Murayama who painted this series of fishes.

California Flying Fish

(*Cypselurus californicus*)

Usual Length, 12 Inches

The California flying fish, one of the largest of its kind, belongs to the family Exocoetidae, inhabitants of warm seas only. Thus the northern traveler is not privileged to witness flights of the species.

Its closest relatives are the halfbeaks, family Hemiramphidae, and needlefishes, family Belonidae, all of which can leap from the water for short intervals. From the family's ability to jump, the power of flight has developed in the flyers, the fins having evolved into sails and the tail into a motor. Similar flying is found in the gurnards and other distantly related fishes.

Had the pioneers in aeronautics studied the fundamental designs of flying fishes instead of birds, the principles of flight might have been mastered much earlier. Indeed, the shape of the hull of the Bellanca plane is like that of the California flying fish, and the Lockheed, a more speedy plane, is similar to another form of flying fish (*Halocypselus*).

Contrary to reports by untrained observers, the fins of flying fish do not flap like birds' wings. There are no muscles in the fins to produce such flapping. A few hours of careful, unprejudiced observation should reveal to the layman the true method of flight.

As the flying fish swims under the water near the surface at high speed, both pairs of wings (fins) are folded back against the body. But as it breaks through the surface, the large fore wings spread wide and then serve as supporting planes. The tail remains in the water, and the body and head are supported in the air at a slight angle.

The tail now vibrates violently from side to side, furnishing the propulsive power to lift the fish from the water and causing also the slight undulating movement of the wings which casual observers have mistaken for flapping. As the "taxi" along the surface progresses, only the lower side of the tail is in the water.

It is estimated that, in taking off, the California flying fish attains a speed of 35 miles an hour. The taxi covers from 15 feet to 45 or more, and the flight from a few feet to a hundred yards. With a long, fast taxi the fish may remain in the air for 30 to 40 seconds, but most flights last for only two or three seconds.

The fish control their flights well both horizontally and vertically, often making excellent use of the wind. Sometimes they will taxi again upon coming down to the water. Dr. Carl L. Hubbs of the University of Michigan found that once in 16 times there were five take-offs before the flight actually ended.

When boats are passing near by, flying fish will take off in great numbers, like grasshoppers suddenly disturbed in a meadow. Per-

haps they are frightened by the vibrations of the propeller. The presence of mackerel, tuna or other voracious fish which feed on them causes large schools to take to the air in an attempt to escape. Probably their ability to take flight has developed as a means of self preservation during the thousands of years they have lived in seas where they are exposed to danger from all sorts of enemies.

During the summer of 1939 I was for several months in the South Pacific collecting specimens for the National Museum. On Swains Island, about 100 miles north of American Samoa, the native Polynesians caught flying fish at night. In their outrigger canoes, they would place cocoanut palm leaves tied into bundles about 12 feet long. Then three or four men would paddle their canoe through the angry surf into the open sea. The cocoanut palm leaves would be set afire and used as a torch to attract flying fish to the outrigger canoe, from which they were speared or caught in small throw-nets.

The next day these flying fish served as bait for trolling for sailfish, tuna, marlin and barracuda. A swordfish caught on flying-fish-baited hooks the week before had rammed its spear through both sides of one of the canoes, but by expert seamanship the fishermen had kept their craft afloat, and their prize fed the village.

My observations on flying fishes of the South Pacific show that their flights are about two to five seconds in duration, the longest flight being 15 seconds and the greatest distance about 115 yards. A flight of 14 seconds usually had about seven take offs. On the average, these flying fish would come in contact with the crests of waves about every second and a half to two seconds and obtain additional speed for further flight.

That flying fish are definitely attracted to light was evident when I suspended a strong electric light a few inches below the surface of the sea. Flying fish, along with other denizens of the deep, would gather around, and when I was quick enough with a dip net or spear I caught several.

One night, while I was on the U. S. S. *Bushnell*, a flying fish attracted by the light coming from a porthole, sailed through it and landed on an enlisted man who was sleeping by the porthole. The fish is now preserved in the collections of the National Museum.

The California flying fish, or great flying fish, reaches a length or more than a foot. It is found regularly in the open ocean from off southern California to Baja California, and sometimes appears in the summertime off northern California. The flying fishes of other adjacent tropical seas and probably this one, too, lay their eggs in floating seaweed. Off our west coast they are not caught commercially, although off Australia and elsewhere flying fish are taken commercially for food.



Painting by Hashime Moraya

WITH TAIL FOR LAUNCHING POWER AND FINS FOR WINGS, GLIDERS OF NATURE SKIM OVER THE SEA

Thrashing the water, the tail catapults the **California Flying Fish** into the air. Instantly tail action ceases, and large pectoral fins spread out wide. When the fish touches the water again, tail action is resumed and the flyer "taxies" along like a seaplane or skipping stone. Successive take-offs seldom number more than four. Most single flights last only one or two seconds, although some of 12 and 13 have been recorded.

Black Rockfish

(*Sebastes mystinus*)

Usual Length, 18 Inches

Black rockfish are members of the family Scorpaenidae, which has numerous relatives, such as the sculpins (Cottidae) and scorpion fishes, in Arctic, temperate, and tropical seas. With 13 spines in the front part of the fin on the back and 5 or 6 spines on the lower portion of the cheek, they are readily distinguishable from other species.

Between six million and nine million pounds of rockfish are landed annually in Pacific American ports. Besides this commercial catch, thousands of pounds are caught by fishermen who are seeking other species and who throw back the rockfish because of the limited market for them.

The black rockfish takes live bait such as herring and small viviparous perch, as well as parts of clams, worms, and artificial lures. It is found from Alaska to San Diego, being rather common along the coast and in certain bays, though it is more abundant near the Juan de Fuca Strait than in Puget Sound.

Like most of the other four dozen or so species of rockfish along the Pacific coast, it frequents rocky shores where it feeds on shrimp and small fishes. Its large mouth adapts it to voracious habits of feeding, and the patches of sharp teeth on the jaws render its victims helpless at once.

Like the surf fishes, all of the rockfishes are viviparous, that is, they give birth to their young. During the winter or early spring the 30,000 eggs or more formed in each large female are fertilized and begin their development. By March, April, or as late as June the tiny young, about a quarter of an inch long, escape into the sea.

Unlike their parents, they do not seek rocky shores for protection but float suspended in the water. They are nearly transparent at first, but by the time they have reached three-fourths of an inch their skin becomes pigmented and then they seek the protection of rocks and seaweeds. They grow to a length of about a foot and a half.

Striped, or Blue, Perch

(*Taeniotoca lateralis*)

Usual Length, 10 Inches

The blue perch, among the most gorgeously colored fishes in the family Embiotocidae, is called also surf fish or viviparous perch (Plate III). The first name was derived from its habit of living in the ocean surf, where it is taken by sportsmen with hook and line. Viviparous refers to the method of reproduction or giving birth to its young.

Other species are found in the bays near wharves where boy anglers catch them by the hundreds. The blue perch may be distinguished by the small alternating narrow rows

of brilliant orange and dazzling purplish-blue stripes extending along the sides from head to tail.

There are 22 species of viviparous perch in the family, one of which has taken up its habitat in fresh water, and occurs only in the Sacramento-San Joaquin River Valleys. Along the North American shores occur 18 marine species, and in Japan three, but they are found in no other place in the world.

The blue perch is known from the vicinity of Vancouver Island and Puget Sound southward to the San Benito Islands, Baja California. Throughout this region it is abundant in the bays and along the open shores, feeding on small shrimps, worms, and other tiny animals. It loves to lurk around wharves where it can pick its food off the piles.

Because of its very small mouth, it is difficult to catch except by means of a tiny hook baited with parts of clams and worms. The commercial catch for all surf fishes is very small, not exceeding 300,000 pounds annually. The blue perch occasionally reaches a length of a little more than a foot in Puget Sound and weighs nearly two pounds, but the average size is only seven or eight inches.

Male and female blue perch differ in the structure of the anal fin just behind the vent on the lower side of the body. In the female this fin is unmodified, but in the male it has a glandlike structure or swelling near its front.

Breeding occurs during the summer, but the eggs do not start developing until September or October. The female has an ovary-uterus in which the eggs are fertilized and develop into embryos between the delicate folds of tissue of this organ.

In Puget Sound, by late November or early December, the embryos are about one-twentieth of an inch long, in February, one-half inch, in March three-fourths inch, and in June or July, just before birth, about two inches.

The number of young produced by one mother blue perch varies from 20 to 90 according to her size. During the six or seven months of gestation the embryos are nourished in a most remarkable manner. The young are bathed in a fluid which is formed from the cell contents of the delicate linings and folds of the ovary-uterus. This fluid is taken into the intestine of each baby blue perch, first through the gill slits, and later through the mouth when it has formed.

The much-needed oxygen is absorbed from the folds and the lining of the ovary-uterus, largely through the fins and skin after they reach a length of three-fourths of an inch.

After that length is attained, and until birth, the fins are greatly enlarged, many times the normal adult size. At birth blue perch appear to have all the characteristics of the adults and are ready to seek food for themselves.



Painting by Hashim-e Murray, a.m.c.

QUEER FISH WHICH GIVE BIRTH TO THEIR YOUNG DWELL BOTH IN THE SURF AND ON ROCKY BOTTOMS

Close to the shoreline, the **Striped**, or **Blue, Perch** (upper left) raises families of from 21 to 90. Each baby fish, about two inches in length, is a perfect miniature of its parents, which usually are about seven inches long. Vastly more prolific are the 14-inch **Black Rockfish** (upper right, and lower) which may bring forth 30,000 offspring at one time, each about one-third of an inch long.

Prawn

(*Pandalus platyceros*)

Usual Length, $2\frac{1}{2}$ Inches

The crustacean family Pandalidae, or prawns, two to three inches long, consists of shrimp-like creatures frequently taken with shrimp along the Pacific coast from Unalaska to San Diego, California. Northward of the Juan de Fuca Strait they are found in shallow water, but southward they occur at depths of from 290 to 1,600 feet.

This type of shrimp, genus *Pandalus*, may be recognized by its long, slender, spiny rostrum; and the dorsal spines extend back on the carapace, helping form a keel or crest.

Shrimp fishermen sometimes inquire why it is that only small males of certain species are caught and all the females are large. Mr. Berkeley has discovered that the shrimp undergo a sexual metamorphosis. Young specimens are always males. At the age of $1\frac{1}{2}$ to $3\frac{1}{2}$ years they become females and probably remain so for the rest of their lives.

According to N. B. Scofield the shrimp fishery started about 1869 in San Francisco Bay, and the first fishermen were Italians. The Chinese, about 1871, introduced the Chinese shrimp net and began to take large quantities of shrimp, most of which were dried and exported to China.

About 1885 public opinion became aroused against the Chinese nets, since they took such large quantities of young fish, and the controversy continued until 1901 when laws were passed closing the shrimp fishing for the months of May, June, July, and August. A test case was carried up through the courts to the United States Supreme Court, the State winning in all the courts.

In 1905 the four-month closed season was removed, but the exporting of dried shrimp was made unlawful. In 1909 a closed season of three months, June, July and August, was adopted, and in 1911 the use of Chinese nets was prohibited; but in 1915 a bill passed allowing their use on south San Francisco Bay. In 1919 the law prohibiting the exportation of shrimp was repealed. Shrimp trawls were introduced about 1915, and both types of gear are now in use in certain areas of San Francisco Bay.

The Chinese shrimp nets are about 40 feet long and shaped like a cone. The mouth is tied in the form of a rectangle four by 30 feet. The last 8 or 10 feet of the small end of the cylinder is about 18 inches in diameter, of one-inch mesh. The larger end is of $3\frac{1}{2}$ inch mesh. These nets are fished for a couple of weeks, then washed and dried before again being used.

The shrimp trawl is a beam trawl, the mouth of which is about 20 by two or three feet, held open by brails and a wooden beam or pole. The net, more or less cone-shaped, is

about 60 feet long and tapers to a foot in diameter at the small end. The wings are about 20 feet long. The net is pulled on heavy iron shoes.

The shrimp are prepared for market in the Chinese shrimp camps. As soon as the shrimp are landed in round baskets weighing 70 to 90 pounds, a fire is started under the shrimp boiler. Several baskets of shrimp are dumped into the boiling tank, along with several shovels of coarse salt. After about 15 minutes of boiling the shrimp are scooped out and again put into baskets for transporting to galvanized wire benches for cooling and screening. The screening is done by shaking a quantity of shrimp in a small hoop made of square-meshed wire varying in sizes from $\frac{1}{2}$ to $\frac{3}{4}$ inch. Small shrimp fall through and are spread out to dry. For market use the larger shrimp are sorted by Chinese women and girls.

In California few, if any, *Pandalus platyceros* are taken along with the shrimp of San Francisco. Instead they are captured in a modified type of octopus trap made out of $\frac{1}{8}$ -inch rattan instead of wire. The trap is four or five feet long with a diameter of three feet, tapering to nine inches at the smaller end. The mouth is in the form of a funnel at the large end with an opening of six inches.

Garibaldi

(*Hypsypops rubicundus*)

Usual Length, 8 Inches

These ocean goldfish, as they are known along the coast of southern California, belong to the family Pomacentridae, or demoiselles. They occur in most warm seas, with many species in the Philippines, Africa, and elsewhere, and are known for their striking colors.

The demoiselles are usually small, active, brilliantly colored fishes that may be seen among the rocks and reefs, in tide pools, feeding on minute organisms but depending on their constant activity and quick movements to escape their enemies. Although several species of this family occur in the warm seas of America, no others except the blacksmith (*Chromis punctipinnis*) are found off California.

The garibaldi, which attains a length of 14 inches, is one of the largest of the demoiselles. Known from Point Conception southward to Todos Santos Bay, Baja California, it lives in the large rock pools and among the rocks of the reefs. The adult is a brilliant scarlet, but the young are dusky scarlet with numerous markings of intensely bright blue. The dorsal fin has 12 sharp spines and about 16 soft rays.

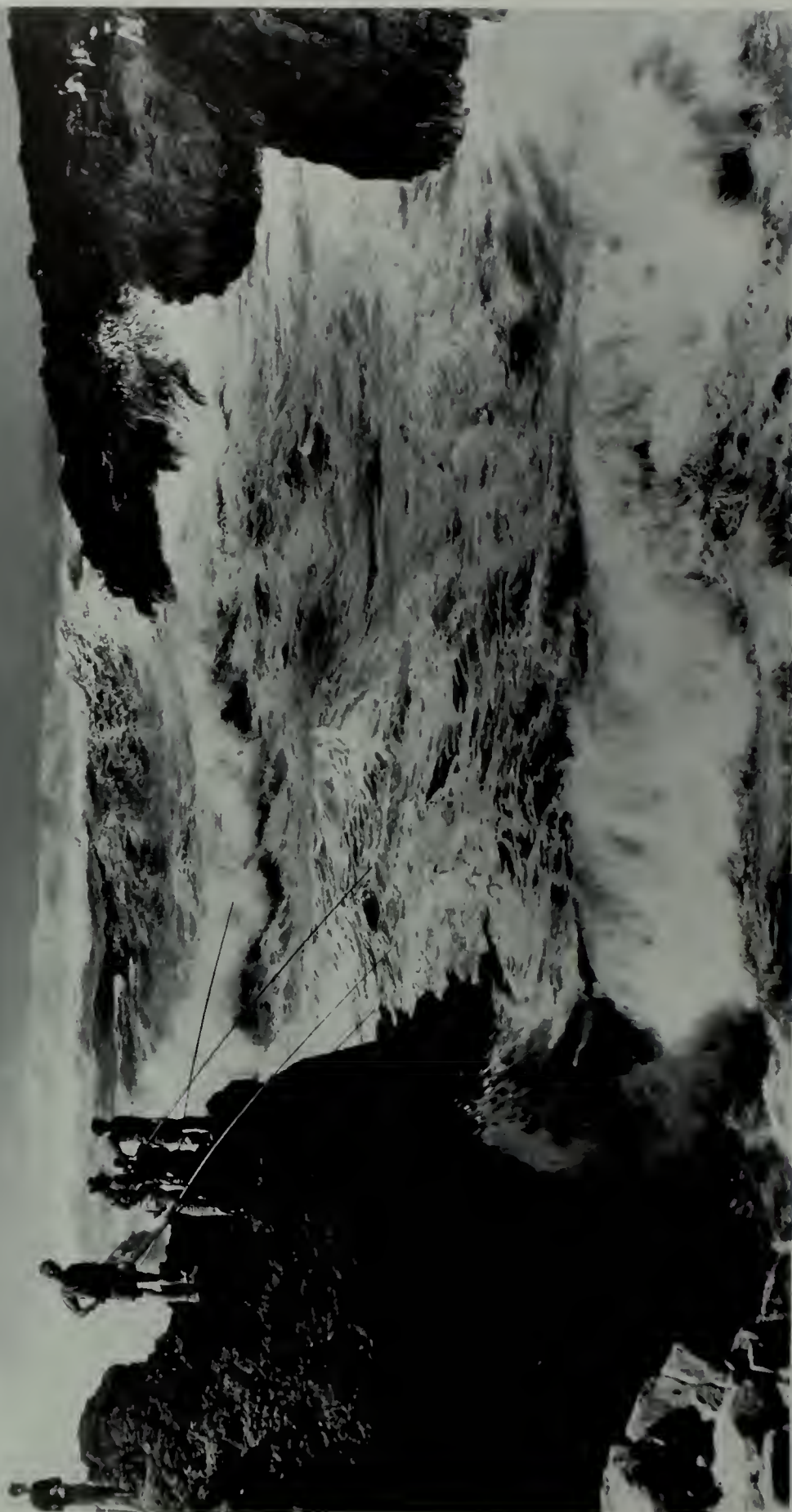
The fish are of slight commercial importance, and are not often taken by anglers. They are the most brilliant species to be seen from the glass-bottomed boats over the submarine gardens off Santa Catalina Island.



Painting by Hashime Murayama

STRIKING "OCEAN GOLDFISH" ARE CONSPICUOUS RESIDENTS OF CATALINA ISLAND'S MARINE GARDEN.

Orange bodies of pugnacious **Garibaldi** are familiar to sightseers who ride in the island's glass-bottom boats. They belong to the demoiselle or rock-pilot family, bright little fishes of tropical seas, and depend upon speed and agility for protection. On the bottom creep **Prawns**, from two to three inches long, members of the vast shrimp family. They have cannibalistic tendencies and live in deep water.



Photograph by Ralph Gifford

INTO THE FOAM OF "DEVIL'S CHURN," OREGON YEAR-ROUND FISHERMEN CAST THEIR LINES

High on the rocks south of Yachats, anglers perch to lure from their hide-outs ling cod, greenlings, surf fish, rockfish, and other denizens of rocky bottoms. Lightness of the poles testifies that gamier fish stay farther out at sea, but even those close in provide excellent sport. All along the rugged 400-mile shore line of the State surf fishing is popular. No license is required for angling in ocean waters, which are under Federal authority.



Photograph from Californians, Inc.

SAN FRANCISCO SHORE FISHERMEN HAUNT BAKER'S BEACH WHEN THE STRIPED BASS RUN

Sardines, clams, and live bait are tempting lures for the game fighters sought by surfcasting anglers near Golden Gate Park. These popular fish also attract sportsmen in scores of fishing boats off-shore, responding to artificial minnows, plugs, or spoons trolled at one to three miles an hour. In recent years the run of stripers has become important commercially.



Painting by Hashime Murayama

LARGE MOUTHS OF RED ROCKFISH COULD HOLD A MAN'S FIST; PATCHES OF SHARP TEETH MIGHT CRUSH IT

Like their black relatives, **Red Rockfish** give birth to thousands of young. Known as Corsairs, these bright orange sea dwellers thrive in deep water from Cedros Island, Mexico, to San Francisco. In wait below for unwary marine animals, which may stray within reach of their pincers, the **Rock Crabs** with hair-fringed feet. Although edible, they seldom reach the markets in commercial quantity, for fishermen have difficulty in luring them from their rocky hide-outs near the shore.

Red Rockfish

(*Sebastes rosaceus*)

Usual Length, 12 Inches

One of the most attractively colored species among the 54 or 55 in the family Scorpaenidae along the Pacific coast, the red rockfish is distinguished from the others by four or five bright rose-pink spots along the back on each side of the fins. The darker border around these spots is deep purple or blood red, never greenish. The rest of the body is orange red, and the fins are rosy, mottled with orange.

This species is found from Puget Sound southward to Cedros Island, Baja California, occurring in considerable abundance off southern California but less commonly off the coasts of Washington and Oregon.

Its large mouth makes it a formidable-looking creature and enables it to feed on herring, perch, crabs, and shrimps, which it swallows whole in one gulp, after crushing them with its "throat teeth," or pharyngeals.

Red rockfish make up a large portion of the commercial catch of six million to nine million pounds taken annually in trawls and by hook and line along our coast and sold almost wholly in the fresh fish markets. They live among rocky reefs as well as in bays at considerable depths, usually near the bottom.

When they are brought up from such depths, their eyes usually bulge and their stomachs protrude from their mouths. This is the result of the sudden reduction of pressure as they come to the surface, and the too-rapid expansion of gases in the pockets behind the eyes and in the large air bladders of the abdominal cavities.

Halibut and other fishes that have no air bladders or very tiny ones can be brought up without apparent harm to them, but those with large air bladders usually are dead by the time they reach the surface. A similar effect is experienced by human divers who come to the surface too quickly, the nitrogen in their blood forming bubbles and causing the serious condition called "bends."

The red rockfish gives birth to its young, as do other members of the genus *Sebastes*. In this genus, there is an obvious relationship between the number of eggs or young produced and the degree of parental care given to the offspring. For example the sharks, which are viviparous, and retain their embryos until they are able to take care of themselves, give birth to one to eight or ten, seldom more at a time. In rockfishes from 20,000 to 45,000 or more larval fish are born, shortly after they hatch in the ovary-uterus of the female, but these transparent little creatures float suspended in the sea water with the other plankton without parental care.

Those fish which build nests and remain for a time protecting the eggs and young—such as the fresh-water bass, the sunfish, the crested

blenny, and certain sculpin—produce from several hundred to a few thousand of eggs. Most sunfishes and black basses select a gravel stone bottom in shallow water of lakes and streams, and carefully excavate a shallow basin-like nest. The eggs are deposited on the bottom and the male remains, fanning them with his fins until they hatch. He protects the young until they are too big for him to manage.

The crested blenny, *Anoplarchus purpureus*, I have observed nesting around the beach stones at Seattle. Its eggs are laid on the underside of a flat stone, and one of the parents remains coiled around the egg cluster until hatching occurs.

Salmon, trout, lampreys, shad, smelt, the grunion, and some other species go to great efforts to migrate to favorable places, and then some build nests for the deposition of eggs. These lay from many hundred to many thousands. Perhaps a well constructed and well placed nest is just as efficient as parental care in protecting the young.

Halibut, flounders, soles, and codfishes, which give no parental care to their eggs at all and make no effort to deposit them in specially prepared nests, usually produce from several hundred thousand to several million. These eggs are usually broadcast in the sea, floating suspended in the water and making up part of the plankton, the latter a food source of all fishes in the ocean.

Thus it appears that the number of eggs laid or the number of young born depends to a large extent on how many will die before they are adults. The pelagic eggs, those that float freely in the water, are produced in the greatest abundance because they no doubt are subjected to the most hazards and it takes only a few out of the millions produced, if they grow to maturity, to propagate the species.

Since the rock fishes combine viviparity with pelagic larval young, apparently to meet the dangers overtaking their progeny, this species must produce from 20,000 to 45,000 eggs.

Rock Crab

(*Cancer antennarius*)

Usual Length, 6 Inches

The rock crab, family Cancridae, has along the Pacific coast eight close relatives, one of them the common market crab. Although edible, it is seldom seen in the fish stalls, probably because commercial fishermen find it unprofitably difficult to catch in sufficient numbers to be worth while. The shores which it inhabits are too rocky.

It can be taken from under and among rocks at low tide from Tomales Bay, California, to Baja California though considerable skill and patience are required for its capture. It measures only about 6 or 7 inches across the back shell, or carapace. Like other crabs it is somewhat inclined to be a scavenger.



Painting by Hashime Murayama

"CHAMELEON OF THE SEA" THE LING COD MIGHT BE CALLED BECAUSE IT CHANGES ITS COLOR TO FIT ITS SURROUNDINGS

Sometimes the upper parts of the **Pacific Cultus** are dark brown, at other times greenish or reddish, depending on the hues of the rocks or kelp in the vicinity. Mottling helps to "camouflage" them. The author has seen violent changes occur in the coloring of the fish when it has been struck light blows. "Cultus" is a Chinook word meaning "worthless," but in this case it is a misnomer, for the fish is valuable as food. Although ling cod bear a superficial resemblance to the true cod of the Atlantic, the species are not related.

The Ling, or Cultus, Cod

(*Ophiodon elongatus*)

Usual Length, 30 Inches

Only member of the family Ophiodontidae, the ling, or cultus, cod is confined in its wanderings to the northeastern Pacific Ocean, and bays from the Gulf of Alaska to San Diego, California. In British Columbia and Washington State it is most abundant.

The ling cod is a large-mouthed, elongated fish, with strongly protruding lower jaw. The teeth are canine-like in both jaws, and the body is covered with small scales. Over and behind the eye are large dermal flaps. The first dorsal fin is composed of about 25 spinous rays, followed by the second or soft dorsal fin of 21 to 24 rays.

Its closest relatives are the greenlings and sculpins, which are of similar habits and habitat, but the true cods are far removed from the ling in structure, classification, and habits. Probably the name "ling cod" was bestowed by European fishermen, who knew the ling of the North Sea. The fish are not related to true cods at all. It would have been no more inaccurate to add to the name the word "trout," as has been done with many of the greenlings, the ling cod's closest cousins.

This species is extremely variable in color, the coloration appearing to be associated with the habitat rather than the sex. When a fish three and a half feet long was brought up alive by a trawler near Puget Sound, it appeared a marbled dark brown with orange spots. The captain struck it on the head with a gaff hook, and like a flash it completely changed its hue, the dark areas becoming light creamy yellow and the light areas brownish.

Female ling cod grow much larger than the males. The largest male on record, caught off British Columbia, was 36¼ inches long and weighed 22 pounds. Females weighing 70 pounds and measuring five feet in length have been taken.

Caught by trolling and in trawls, these large fish are profitable prey for commercial fishermen, the annual catch landed in American ports ranging from 1,500,000 to 3,000,000 pounds. Virtually all are marketed fresh, but if the demand slackens they are subjected to quick freezing, glazed with ice, and stored, with little loss of flavor.

The smaller fish are dressed and sold to restaurants and hotels or cut into steaks for home consumption. Exceptionally large fish are filleted. When properly fried in deep fat, they are delicious.

Ling cod are caught commercially by the otter trawl, which consists of a long bag-like net, with 5-inch stretched mesh at the mouth and 4-inch stretched mesh at the small end or cod end. The float line is supported by corks, and the bottom line is heavily leaded. Attached at each side of the mouth of the net are otter boards measuring 3 x 5 feet, and

about three inches thick. When these boards are set at the proper angle and hauled through the water, they spread the net.

Another method of catching ling cod is by jigging. The jig consists of a light metal bar, three or four feet long, suspended in the middle by the main line. Below the bar on the main line is attached a two-pound weight. At each end of the bar is attached a short piece of line or snood, at the end of which is fastened a hook three inches long. This hook is baited with live herring, kept in live-wells on the boat. By carefully passing the hook under the vertebral column of the bait herring, the fisherman avoids killing it, and it can still swim for some time.

This baited gear is now lowered to a reef, often to a depth of 40 fathoms, and then raised above the bottom a few feet. Jigging consists of raising and lowering the baited jig to attract the attention of the prey. Since the ling cod has such a large mouth, the herring and hook are well swallowed when he strikes.

The ling cod occurs from shallow water to a depth of at least 1,200 feet, large fish having been taken on halibut gear set at the latter depth off the Queen Charlotte Islands.

In the spawning season, from about the middle of December to March, both sexes leave the deep water and seek rocky areas where a strong tidal current flows. The female selects for her egg-laying a crevice in the reef or a position between two large boulders ten feet or more below the surface. Occasionally a mass of eggs is laid above the low tide level, but these eggs spoil from exposure. They are whitish, with very thick, tough shells, and of a size larger than usual for fishes, measuring a little more than one-eighth of an inch in diameter when deposited.

The eggs are contained in two ovaries, and the number laid by one female each year depends on her size. Counts by G. V. Wilby show that a 30½-inch female had about 60,000 eggs; one 36¾ inches long had 263,000; and one 41 inches long had 518,000.

The eggs, so firmly attached to the rocks and one another that they appear as a compact mass, are watched over and protected by the male, which keeps stirring the surrounding water with his powerful fins, vigorously driving off intruders by biting or bunting. A fish spear put down by Mr. Wilby to detach some eggs was so sharply bitten by the protecting parent that teeth marks were left on the wooden handle. It is thought the eggs require about six weeks to hatch. At the end of this period the male leaves the nest.

From early stages to full maturity these fish feed voraciously upon all kinds of organisms. The tiny young eat crustaceans or shrimp-like animals, and the large immature feed on young herring, smelt, and other small fishes. The stomachs of large adults contain herring, anchovies, sand lances, cod, small flounders, crabs, shrimp, and squid.



Painting by Hashime Murayama

SPLASHES OF IREDESCENT BLUE EMBLAZON MALE GREENLINGS; QUIETER TONES OF RED AND BROWN SPECKLE THEIR MATES

Often incorrectly called rock trout, **Greenlings** (male above, two females at right) are valued as filets on the Pacific coast. Anglers seek them around rocky headlands and sometimes in the surf near reefs. **Ghost Shrimps** are erroneously called "crawfish" by dealers who sell them for bait. Long, thin-bodied, and translucent, they contrast with the black mud in which they live. Sometimes they burrow a foot below the surface, where they turn around simply by rolling themselves up.

Kelp Greenling

(*Chiropsis decagrammus*)

Usual Length, 14 Inches

The kelp greenling, sea trout, or rock trout, of Pacific North American shores, belongs to the greenling family, Hexagrammidae, related to the ling cod, sculpins, and rockfishes. It differs from them and most other fishes, having five lateral lines on each side instead of the usual single one along the midside.

Living around rocks among rank growths of kelp and other seaweeds (algae) in bays, around islands, and off the coast from Kodiak Island, Alaska, to Point Conception, California, it is known to most anglers, who catch it on hook and line with clams, worms, or bits of fish. Although it reaches a length of 18 inches, and a weight of two to four pounds, it is unimportant commercially. Most of the fish are landed at San Francisco and sold on the fresh fish market.

To the north, in Oregon and Washington, in Puget Sound a small catch is made by anglers. Often the flesh has a pale blue-green tinge that disappears upon cooking. The flavor of greenlings when properly prepared is excellent and enjoyed by many.

The color of the sexes is variable, that of the male brownish or coppery with iridescent bluish spots on the head and front part of the body. The females are grayish blue covered uniformly with round, reddish-brown spots.

One of the first group of fishes of the North Pacific to be made known to science was in the family Hexagrammidae, kelp greenlings. Five of the known species were described by Pallas in 1810 and the sixth by Tilesius in 1809.

Perhaps much of the credit for the recent advancement in our knowledge of fishes should go to the pioneers in ichthyology along the West Coast and in the North Pacific generally. The first person associated with the study of the fishes of the North Pacific was the naturalist Steller, who visited Alaska in 1731. The Russian Government, previous to 1811, also employed Pallas to study the North Pacific fishes, and incidentally he discovered in his trip across Siberia a mastodon frozen in the ice. About 1830, Dr. Gairdner, a physician living in Astoria, Oregon, at the mouth of the Columbia River, collected fish and sent them to Sir John Richardson of the British Museum for description.

It was not until after the gold rush of 1849 that exploration of the fish fauna of the West Coast began in earnest. First Dr. W. O. Ayers, about 1852, and then Dr. W. P. Gibbons of Alameda, California, became interested in the unique fish of our Pacific Coast, the viviparous perches, or surf fishes. Dr. Charles Girard, Dr. J. G. Cooper, and George Suckley are well known names associated with the early work on western fishes.

From 1880 on to the end of the century the U. S. Fisheries Steamer *Albatross* made extensive collections in the Pacific which have been made known to science mostly through Drs. Jordan, Gilbert, Evermann, T. H. Bean, and several others. The whole deep-sea fauna of the Pacific was unknown until these explorations, which revealed very strange and almost incredible forms.

In recent years, noteworthy among the fisheries laboratories of the West Coast that have contributed accurate original knowledge concerning fisheries and fishes are the California State Fisheries Laboratory, Terminal Island, near San Pedro; the International Fisheries Commission, for the study of halibut, with offices and laboratory at the University of Washington, Seattle; U. S. Bureau of Fisheries Laboratory at Seattle and with other offices at Stanford University; Pacific Biological Station at Nanaimo, British Columbia; and the Fisheries Experimental Station at Prince Rupert, British Columbia.

The University of Washington and Stanford University at present are the leaders in fisheries education and ichthyology on the West Coast. All of these important centers for fisheries and ichthyological research were started during the last twenty to thirty years, with the exception of Stanford University, which has had a long celebrated history.

Ghost Shrimp

(*Callinassa californiensis*)

Usual Length, 3 Inches

The ghost shrimp, family Callinassidae, lives in burrows in the mud and sand from Vancouver Island, British Columbia, to the mouth of the Tia Juana River, San Diego County, California. From these burrows it may be obtained by digging at low tide.

It is a very soft-shelled crustacean, more or less transparent, so that the internal organs and even the beating of the heart may be seen through its shell. Its crablike legs are used for seizing its food, which consists mostly of worms. The young are delicate orange to deep rose pink, but the adults are lighter.

Although used as bait, the ghost shrimp is disliked by oyster growers in the Puget Sound region of Washington because of the harm it does to spat, or small oysters that have recently settled and fastened themselves on shells or rocks. On bottoms where the creature lives, baby oysters are often smothered when its sand and mud mounds (4 to 8 inches in diameter and 1 to 3½ inches high) are washed over them by wave and tidal action.

The burrows also perforate artificial oyster-bed dikes, causing the water to drain out and subjecting the oysters to drying conditions. The Japanese oyster, now so abundant on the Pacific Coast in certain districts, is not so much affected as the delicious little native oyster.



Painting by Hashime Murayama

MALE RUBBERLIP PERCHES (UPPER) REVEAL THEIR SEX BY FLESHY GLANDS ON LOWER FINS

Among most fishes males and females look alike, but sex of the **Rubberlip Perch** and other members of the surf-fish family may be determined externally. Thick, drooping, and ragged lips have given this shallow-water habitué its name. **Marbled Sculpins** (below), also known as **Cabezone** or **Blue Cod**, have flaps of skin somewhat resembling feathers above their eyes and near the tips of their snouts.

Marbled Sculpin or Cabezone*(Scorpaenichthys marmoratus)*

Usual Length, 16 Inches

The marbled sculpin, or cabezone, also known as the blue cod and bullhead, is one of the commonest of the shallow-water sculpins, family Cottidae, found along the western coast of the United States.

Most of its hundred or more relatives inhabiting sandy to rocky shores and tide pools of bays and reefs along the west coast are usually less than eight inches long and as a group are of slight commercial importance save for bait. Some live at great depths in the sea and are never seen except when brought to surface in dredges or trawls.

The cabezone, however, reaches about two and one-half feet in length, and many weigh 20 to 25 pounds. The only other species of its family that attains this size on the Pacific Coast is the giant sculpin. These two forms may be distinguished at once by the number of rays in the pelvic fin, one spine and two soft rays in the giant sculpin, and one spine and five soft rays in the marbled sculpin.

The flesh of the cabezone is often of a slightly bluish tinge but is highly esteemed by anglers. The fish is caught readily on hooks baited with parts of clams or fish. It occurs from Puget Sound to San Diego, California.

Its color is highly variable, usually mottled with rich dark brown or reddish brown, and greenish above, lighter below. It is often variously spotted with reddish or creamy yellow. Fish living in the kelp and fucus beds are usually predominately brownish, while those inhabiting green algae or eelgrass are mostly greenish. In fact, the marbled sculpin imitates the colors of objects in its immediate surroundings so well as to be difficult to see except in motion.

The skin, without scales, has a wrinkled appearance. The head is large, with numerous spiny projections, as in most other marine sculpins. The mouth, too, is large, with sharp teeth, enabling feeding on anything available, such as small fish, sculpins, crabs, and shrimps. Above the eyes and on the snout are large featherlike flaps of skin, or tentacles.

The marbled sculpin in the Puget Sound region has been found to spawn during the spring, usually March and April or later. It deposits its eggs, poisonous if eaten, on the tops of large rocks or old piling extending from six inches to a foot or two above the beach. The eggs, small and variable in color, but usually yellowish to wine red or purplish, adhere to one another compactly.

At low tide a single exposed rock or pile may display several distinct batches of eggs, each batch varying in color and in a different stage of development. Eggs laid a week or more are in an advanced state, and if placed in a jar of sea water, after exposure to sun-

shine, they will hatch immediately, like popping corn. The larvae, pale greenish and nearly transparent, swim about actively in the jar. If not too crowded and if kept cool they will live for several days. Along the beach in the vicinity of the piling older larvae have been taken in plankton nets.

Rubberlip Perch*(Rhacochilus toxotes)*

Usual Length, 10 Inches

The rubberlip perch, common from San Francisco to San Diego, California, belongs to the surf fish family, Embiotocidae. Its exceedingly thick, whitish or pink lips, silvery sides, bluish or blackish back, (the scales often tipped with blackish), and the black tips to the median fins on the back and under side as well as the pelvic fins, help distinguish it from other surf fishes of the region. Its long dorsal fin has about 10 spines followed by about 23 soft fin rays, and the three anal spines and about 30 soft rays. Its teeth are strong and wide set.

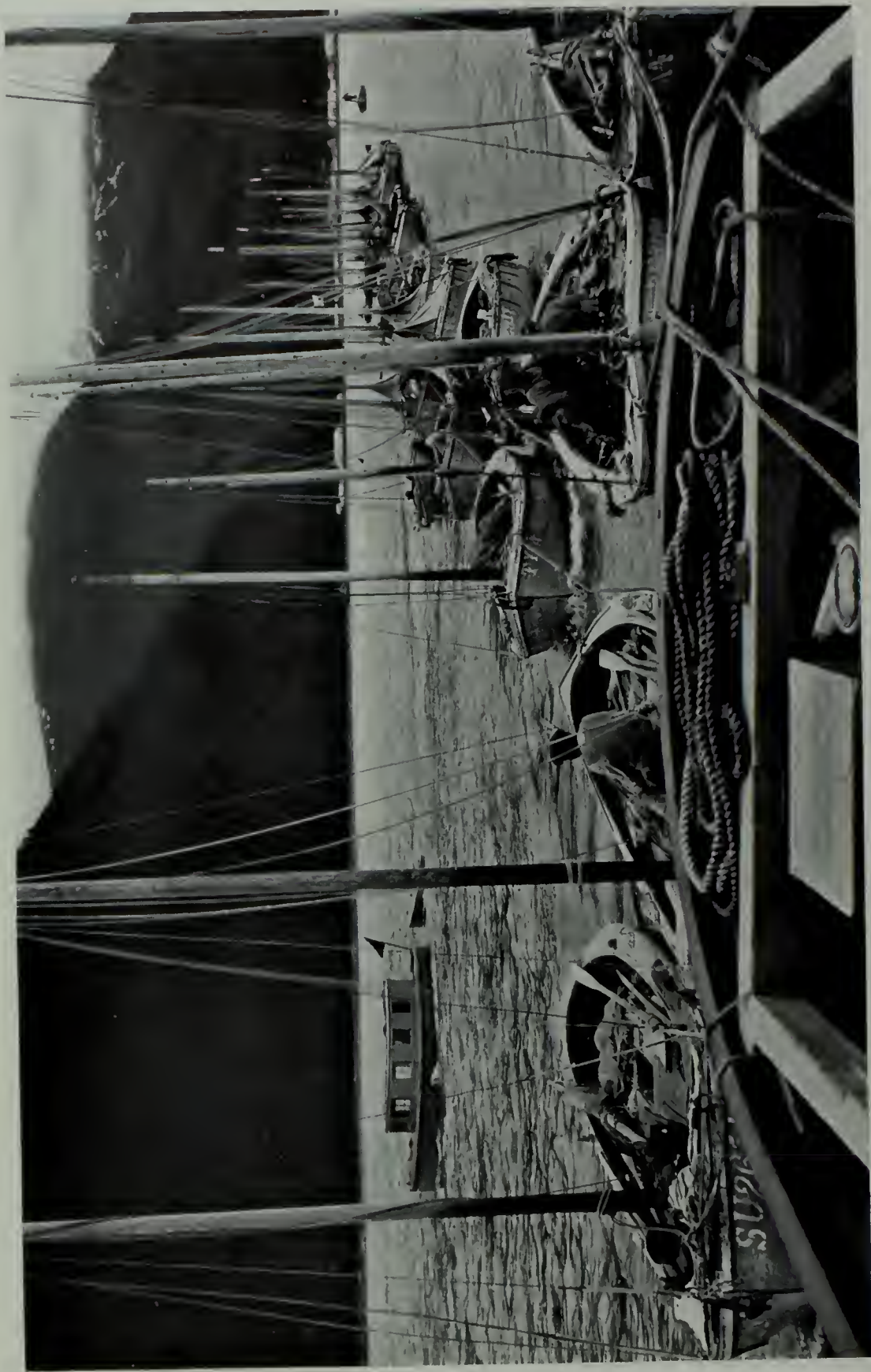
In this family mating occurs in the late spring or summer just after a brood is born. Since these fish give birth to their young, they are called viviparous, and fertilization by the sperm occurs internally. The live spermatozoa are carried in the ovary-uterus of the female until Autumn or early winter at which time the ova mature and are fertilized.

The developing embryos, numbering from several to about 90 in certain species are born in the following spring or summer. During their period of embryological development they are retained in the ovary-uterus among its numerous very delicate folds of fine tissue or membranes. The cells forming these membranes give up their contents to form a fluid in the ovary-uterus which bathes the embryos and nourishes them.

The absorbing of enough oxygen to keep the embryo alive when it is half grown is accomplished through its fins, which increase to many times their normal size and are supplied by a host of tiny blood vessels. Shortly before the embryos are born, these fins are reduced in size, and at birth the young appear like miniature adults.

In nearly all species of viviparous perches, the males may be recognized by the glandular-like structure on the anal fin. This organ consists of a few of the rays of the anal fin, enlarged and swollen to form a gland.

The fish is taken on hook and line, but the hook must be very small, since the mouth of the rubberlip perch is not large. Pieces of worms, clams, or mussels make good bait. Though reaching a length of a foot and a half, the species forms only a small part of the commercial catch of surf fishes along the coast. The flesh of surf fishes is edible but is considered rather watery and lacking in flavor.



THE FLEET OF SALMON SAILBOATS IS TOWED OUT TO FISHING GROUNDS

If any owner attempts violations of rules, he will be quickly checked, for Canada, like the United States, exercises close supervision over the industry. Many of the finest spawning streams are located in British Columbia. The Canadian Government Fisheries Patrol boat is seen on the left.



SAN DIEGO ANGLING ENTHUSIASTS MARCH TRIUMPHANTLY ASHORE WITH PRIZES CAUGHT NEAR HOME

Among the fishes taken are dolphins, tuna, albacore, and California yellowtail. From the docks, excursion boats daily carry throngs of fishermen and women to the lucky "grounds" off the Coronado Islands. One can make the trip for a small price, and return in the evening with a good catch and, better still, a glorious feeling of relaxation, after a day of fun and freedom from care.

White Sea Bass

(*Cynoscion nobilis*)

Usual Length, 40 Inches

The white sea bass is really not a bass at all but belongs to the croaker family, Sciaenidae. On the Atlantic coast this species has a very close relative, the weakfish or squeteague, well known to anglers and commercial fishermen.

The white sea bass is steel blue above, silvery on the sides, and white below. A dusky spot occurs at the base of the pectoral fin. The cross bars on the young disappear on the adults. The first dorsal fin has 10 spines, and the second dorsal one spine and 21 to 23 soft rays; the anal two spines and nine soft rays.

The members of this family are carnivorous, feeding largely on fish, such as smelt, herring, anchovies, sardines, squids, and crustaceans. They are abundant in warm and tropical seas, with 45 or more species off Central America. All the croakers and weakfishes are classed as food fishes and some of them as game fishes.

The white sea bass ranges farther north along our coast than any other member of the family, being common off Vancouver Island at certain seasons, but it is only a tourist in southeastern Alaska. To the southward it does not go beyond the Gulf of California.

Off California it is one of the valuable food fishes, reaching a weight of 90 pounds or more. It has firm white flesh that is delicious. The average annual catch is between one million and two million pounds.

Pilchard or California Sardine

(*Sardinops caerulea*)

Usual Length, 10 Inches

Called pilchard in Washington and British Columbia, and California sardine in California, this fish belongs to the great group of herring and shad classified in the family Clupeidae. Its close relatives are the anchovies, tarpon, gizzard shad, and numerous others. Fossil herringlike fishes are found in the Green River shales of Wyoming, indicating the great age of the ancestral stock.

About the only fish that the California sardine could be confused with along the West Coast is the Pacific herring, *Clupea pallasii*. This latter species has about 40 gill rakers on the lower arch of the first gill; a dusky peritoneum; about 38 to 45 rows of scales on the side of the body; and no striae on the operculum. In contrast the pilchard, *Sardinops caerulea* has from 50 to 60 rakers on the lower arch of the first gill; a black peritoneum; and about 53 rows of scales; and the operculum has 7 long striae extending downward and backward.

From the shad, *Alosa sapidissima*, which was introduced on the Pacific coast many years ago, both the sardine and herring may be distinguished by the latter having the ventral edge of the abdomen somewhat rounded, in-

stead of having strong, sharp-edged ventral scutes, and a much compressed abdomen.

The most northerly record of the pilchard is off the Queen Charlotte Islands, and the most southerly in the Gulf of California. Throughout this area it occurs in large schools. The fish are caught in purse seines 1,200 to 1,350 feet long and 120 to 130 feet deep, fitted with purse lines or drawstrings. When the nets are set around a school of sardines, the bottom of the seine is closed or pursed, and the purse seine, floated at the surface in the sea with corks, does not allow the fish to escape. The bottom line of the net is leaded with the sinkers, the total weight of which exceeds a half ton. Along this lead line are tied about every 25 to 30 feet pieces of rope 12 feet in length to which are fastened 4½-inch brass rings. Through these runs the purse line.

In daylight schools of sardines are detected by black spots they cause in the water or by their breaking the surface from jumping; and at night by the luminescence they cause in the water when swimming. After the school has been caught, it is brailed into the boat or on scows towed for that purpose.

Single catches up to 100 tons are made, but the average haul off British Columbia is 35 tons. This represents an enormous number of individual pilchards, since the average size is about 10 inches and the average weight about 4 to 4½ ounces. In California the sardine is caught in a similar manner.

The commercial catch for the United States several years ago averaged from 300 million to 500 million pounds annually. However, the catches in California, Oregon, and Washington have been: 1935—1,184,304,000 pounds; 1936—1,496,304,000 pounds; and 1937—907,862,000 pounds. This is the greatest weight taken of a single species among all commercial fishes in North America.

Almost the entire catch is reduced to oil or fish meal. The pilchards are unloaded at reduction plants and there passed through steam cookers from which they go to a continuous press where the oil and water are separated from the flesh and bone residue. The oil is allowed to flow into tanks to settle and the water into the sea. The solid portion is dried, and sacked as fish meal. Fish meals have proved of great value for chicken feed and for fertilizer.

An examination of the stomach contents of sardines has shown that about 200 species of floating or suspended small plants and tiny animals are eaten. Small one-celled green plants form nearly 40 per cent of the total food, and the remaining items are tiny animal organisms.

The California State Fisheries Laboratory and the Province of British Columbia have carried on extensive studies of the pilchard fisheries and of the life history of the species. The age of the fish cannot be read with certainty from the scales or "ear bones."



Painting by Hashime Murayama

THE SILVERY SARDINE (ABOVE) THRIVES DESPITE MAN, BIRD, AND BIG FISH

On moonless nights the luminous gleam of the water about the **Pilehards** as they swim close to the surface betrays the presence of vast schools to fishermen. The fish feed on minute marine life, often close to shore. Yielding food, oil, and meal, sardines are the most important commercial fish on the California coast. The large **White Sea Bass** frequently weigh as much as 80 pounds.

Albacore

(*Germo alalunga*)

Usual Length. 36 Inches

The albacore, family Thunnidae, is closely related to the mackerels, family Scombridae, all of which have crescent-shaped tail fins that furnish strong motive power for swimming. It may be distinguished from all other tunnies or mackerel by the great length of the pectoral fins, which reach past the front of the anal fin and are nearly half the length of the fish without the tail fin. So noticeable is this peculiarity that the casual observer might fancy that the fish wears a shawl.

The one single character that distinguishes all of the mackerels and tunnies is the series of finlets behind both dorsal and anal fins. Other non-mackerels have finlets, too, such as the sauries, family Scomberesocidae, but these fish have only a single dorsal and anal fin instead of two dorsals and one anal fin.

The albacore has about 14 spines in first dorsal, 2 spines and 12 soft rays in second dorsal fin and 8 finlets; on the ventral side the anal has 2 spines and 12 soft rays followed by 7 or 8 finlets. The color is dark blue above shading into dusky and silvery below.

The Albacore, similar to the other mackerels and tunnies, are fishes built for great speed in the water. All of the fins fit into grooves, the pectoral, too, lies in a small depression on the side of the body; the jaws fit into grooves, so that the entire fish is almost perfectly streamlined.

It inhabits all warm oceans, and is not common in the Atlantic off the coast of the United States. Southern California waters have it in abundance, and in recent years it has been caught off Oregon and Washington in large quantities. Like most of its relatives, it is a denizen of the open seas and seldom enters bays or comes close into shore.

The albacore fishery is dependent to a marked extent on the activity of the fish, its acute vision, and its hunger. Large sea-going powerboats, carrying several men and plenty of ice, go long distances for the catch. Live bait, such as sardines and anchovies, are caught and kept in live tanks on the boat. In the ocean the albacore feeds on sardines, anchovies, squid, and other small fishes of the high seas.

As the boats progress seaward, rag lures or "jigs" are dropped a hundred feet or so astern and towed rapidly just below the surface until a strike indicates that a school of these beautiful dark steel-blue fish are at hand. Live bait is thrown quickly overboard in dipnetfuls while the boat is being stopped. "Chumming" with live bait attracts and holds the school of albacore near the boat.

Hooks tied on hand poles and lines are baited and dropped overboard into the school, which swims about violently beside the boat. As long as the fish remain, they take the bait rapidly,

but they disappear as swiftly as they came, and trolling with the jigs must be continued.

The albacore puts up a violent battle when hooked, and in recent years big game fishermen in increasing numbers have taken to pitting their skill against it with light tackle. Many consider the albacore as sporting an opponent as the leaping tarpon.

These schools of albacore are most abundant from May to December, though a few may be taken off southern California all year round. The average weight is about 20 pounds, but certain individuals weigh as much as 80 pounds.

As a food fish the species has gained importance since it has been canned under the name of tuna. It has found favor with housewives because it is easily prepared and makes an excellent salad comparable in flavor to chicken. Both white-meat and dark-meat tuna may be purchased in the food markets.

Several years ago the annual commercial catch was from 300,000 to 700,000 pounds, but in 1937 more than two million pounds were caught and in 1938 more than five million pounds. The bulk of these fish was caught off the coasts of Oregon and Washington.

The migration of the albacore is yet a mystery, and when it leaves our Pacific Coastal waters its journeyings in the Pacific are not known. Neither are its spawning habits known, although specimens from near the Hawaiian Islands have been found to have ripening ovaries in the late summer.

In recent years the demand for tuna has been so great that tuna boats capable of crossing the Pacific have been built, and now they fish several thousand miles from their home ports. These modern boats are insulated with cork, being in effect huge refrigerators, and have bait tanks holding as much as six tons of sardines that will live for at least three weeks. The crew have light, airy quarters, equal to many passenger boat staterooms; no longer do these fishermen sleep in dark, poorly ventilated, oily smelling cubbyholes.

The albacore is taken by sportsmen and anglers on spoons, bone jigs, feathers, and bait, up to speeds of 8 or 10 miles an hour. It is an excellent fighter on light tackle, and the average size caught is from 15 to 20 pounds.

Kite fishing for tuna and albacore along the Pacific coast is a well-known sport. When a school is sighted, the angler runs his boat down wind for a short distance, then turns it about and sends up a box kite. The kite string is tied to a small thread across a loop in the leader in such a way that the thread breaks when the tuna or albacore strikes the baited hook fastened to a line run out about 200 feet from the boat.

The boat is turned into the wind and steered so that the wake does not cross the school of fish, but the bait passes over it. When the fish strike, the kite is released and is recovered as soon as the albacore or tuna has been landed.



Painting by Hashime Murayama

MYSTERIOUS AND ERRATIC IS THE PRIZED ALBACORE, "CHICKEN OF THE SEA"

Where the **Albacore** spawns and breeds, no one knows, nor where it goes when it leaves United States shores. Originally it was the only tuna used for canning 25,000,000 pounds of "white meat" being tinned in one year. But so scarce did they become in 1928 that the wholesale price rose to \$300 a ton. Smallest of the tunas it is an excellent fighter on a light tackle, and will take a trolled lure at speeds of 8 or 10 miles an hour.

Opaleye or Greenfish

(*Girella nigricans*)

Usual Length, 10 Inches

The opaleye belongs to the family Kyphosidae, or rudder fishes, which are mostly tropical shore fishes, in both the Atlantic and the Pacific. Like other members of the family, they have incisorlike teeth and are herbivorous, feeding on green and brown algae, which, covered with hydroids and bryozoans, grow in the rocky pools where they live.

The opaleye is light or dark green, the shade depending on light conditions, and there is a characteristic white blotch on the back at each side of the dorsal fin. The dorsal fin has about 14 spines and 14 soft rays; the anal 3 spines and 12 soft rays.

The eye is opalescent blue, the body olive green, grayish brown below. The young have a whitish spot on each side of the back.

The greenfish depends upon its great activity to escape its enemies. Rather small and compactly built, it is a fast swimmer.

This species is of little value commercially, or to anglers, since it is caught irregularly, or only incidentally, in nets, and occasionally on hook and line baited with bits of clams, worms, or fish. Its maximum length is about 17 inches. Its flesh is of fair quality and of a good flavor.

Spiny Lobster

(*Panulirus interruptus*)

Usual Length, 12 Inches

The spiny lobster, family Palinuridae, is common along the shores to a depth of 120 feet from Point Conception, California, southward to the coast of Mexico, but north of Point Conception it does not thrive. It lives among rocks, hiding in crevices and in kelp, which furnishes protection and food. It averages two or three pounds, the record size being 17 pounds.

The spiny lobster is caught commercially in lath boxes or other traps. A hole in the top is fitted with sharpened laths pointing inward to prevent escape of the captives. Baited with decaying fish, the traps are set in 10 to 50 feet of water in the summer, but deeper in the winter. The traps are marked with buoys to aid the fishermen to find them again, for he lifts 15 to 25 traps daily, and without the buoys to guide him he would miss many a catch.

The lobsters brought to market are sorted into groups according to size. The smallest range in length from 10½ to 14 inches, while the bulls are more than 14 inches in length; yet the smalls bring a few cents more a pound on the market.

They are put into metal baskets made of strap iron holding about 500 pounds, and lowered into vats of boiling water containing about 200 pounds of salt to each 420 gallons of

water. After 20 minutes they are lifted out, the lobsters having turned scarlet because of the action of the heat, then dumped on platforms for washing and cooling. When dried and cooled, they are packed in wooden boxes with ice for shipment to cold storage or the market.

In California the annual catch is about 1,300,000 pounds, and in addition many are caught off the coast of Mexico.

Spawning occurs from May to the end of the summer. The eggs are attached to the swimmerets, as in the fresh-water crayfish, and number from 250,000 to 500,000 on large females. They hatch in nine or ten weeks. The females seek the shelter of rocky places near shore during the spawning period.

Larval crustaceans pass through several stages which are not at all like the adults. They molt, or shed their shells, any time when they are too big for them, by simply crawling out through a slit on the upper side near the first abdominal segment. The new outer skeleton is soft for a time, so that the spiny lobster is easy prey for its enemies until its shell hardens. There are several such molts before it reaches a commercial size at an age of seven and a half to 10 years.

Spiny lobsters can walk forward, backward, or sideways, and swim backward powerfully by means of their tail fans.

During the summer of 1939, while I was in the South Pacific Ocean collecting natural history specimens, mostly fishes and crustaceans, for the United States National Museum, I found spiny lobsters to be rather abundant on the coral reefs of Enderbury, Hull, and Canton Islands. The species which I collected probably was *Panulirus penicillatus*.

At night I would take a strong flashlight or gasoline lantern and walk out on the reef at low tide. The coral reefs, from 200 to 400 feet wide around these barren atolls, are smooth and flat except the outer margins, which are deeply channelled. Between the channels are rank growths of coral. It is among these channels and coral heads that the spiny lobster lives during the day. But at night it comes out upon the flat part of the reef in water as shallow as six inches.

By slowly walking along with the flashlight beam directed downward against the reef, I would soon find spiny lobsters. These I collected by two methods. With a woolen or canvas glove on my right hand, I would reach down in the foot-deep water and grasp the lobster firmly by its carapace. Instantly the crustacean would throw back its long, very spiny tentacles and begin moving them back and forth over my glove.

Gloves were adopted after the first attempt without them. Upon capture, the lobsters were placed in a canvas bag, and they would produce by means of their tentacles and carapace a squeaky, humming sound, audible at



Painting by Hashime Murayama

WITH EYES OF OPALESCENT BLUE, GREENFISH SURVEY THE HAUNTS OF LURKING ROCK LOBSTERS

In tide pools along the shores from Cape San Lucas to San Francisco, **Opaleyes** are abundant. They are a branch of the rudderfish family and feed mostly on seaweeds covered with small marine animals. In crevices dwell **Spiny Lobsters**, eagerly sought by fishermen. So great have the annual catches of these crustacean delicacies become that California has enacted conservation laws to protect them.

considerable distance. A poacher would have difficulty getting such noisy prey home undetected.

The second method of capture at night with a light was by use of a dipnet. Taking advantage of the habits of lobsters, which when disturbed swim backwards by the powerful movement of their tail fans, I placed a dipnet 18 inches in diameter about 12 inches behind them and then with my foot touched their tentacles. Thus disturbed from in front, they would dart backward into the net and before they could get out I would place them in a canvas bag.

Walking about the coral reef at night is precarious, for many of the channels are 50 feet deep or more and the coral along their edges is undermined by the eroding action of the surging sea. When all about it is almost totally dark, the rim of the island, only a few feet above the sea, cannot be seen. I could tell the direction of the pounding sea only by the roar of the surf. Thus when I began to get into water that was dangerously deep I walked away from the roar of the surf until I came into more shallow water.

Spiny lobsters were not the only animals seen and caught on the coral reefs at night. The shovelnose lobster, *Parribacus*, was taken in a manner similar to that followed with the spiny lobster. Silver gars, halfbeaks and mullets were common too and were caught with ease as the light blinded them as it did the lobsters.

Electric Ray

(*Tetranarce californica*)

Usual Length, 12 Inches

The electric ray, or crampfish, only member of the family Torpedinidae that occurs along our Pacific coast is found in moderately deep to shallow water from Nootka Sound, Vancouver Island, to San Diego Bay, being very rare northward. Its close relatives are the skates, rays, and sharks, but on the Atlantic Coast we find an electric ray or torpedo fish difficult to distinguish from the Pacific form.

The electric ray has a broad circular disk, without spines or prickles anywhere. The color on the dorsal surface is bluish black with small black spots distributed generally over the disk. The under side of the body is pale in color. There are two small dorsal fins; the first is situated anteriorly to the posterior tips of the pelvics, and the second dorsal near the tips of the pelvics.

The torpedo is a bottom dwelling fish, eating whatever is convenient.

It is ovoviviparous; that is, the eggs produced are fertilized internally, have a well developed covering or shell, and hatch within the body of the parent.

The electric rays may be recognized by their broad, circular bodies and long tails, covered with smooth blackish skin above, whitish below. Placed at the sides of the head and gill cham-

bers, the electric glands occupy a large portion of the region, extending nearly from the upper to the lower surface. Each organ is composed of several hundred large, honeycomblike cells, or vertical hexagonal prisms, filled with a nearly clear jellylike substance.

The whole gland is covered with skin and is not easily apparent externally, but the electric shock it generates is sufficiently strong to be disagreeable and painful to the hands or to the bare feet of bathers. Fortunately for the bathers who frequent the southern California beaches, few of these torpedoes are hiding partly buried in the sand.

This living battery shows all the properties of electricity, the discharge registering voltage and current on electrical instruments. Although the shock is powerful enough to render man uncomfortable and perhaps to stun fish, it is not so strong as that of the South American fish known as the electric eel. This electric eel, an entirely different sort of fish from the electric ray, is only a few inches in diameter and reaches a length of three or four feet. It gives off an electric charge which stuns fish within a few feet of it in the water and which is very painful to man.

Unlike the electric ray or torpedo on our coast whose battery is soon fatigued, the electric eel gives off a series of shocks every second or less that may continue for hours without loss of power. A potential measured recently by the staff of the New York Aquarium was well above 200 volts.

The electric ray ranges in length from a foot (average) to three feet and a weight of 75 pounds or more. It is common from central California southward to Santa Barbara Channel and is of no commercial value at present.

Sheep Crab

(*Loxorhynchus grandis*)

Usual Length Across Back, 6 Inches

Sheep or kelp crabs belong to the family of spider crabs, Majidae, with numerous members occurring along the shores of Pacific North America. They are noted for their habit of decorating or masking themselves by placing, with their long, ungainly legs, bits of seaweed, sponges, or other objects on their backs. This disguise probably aids the crab to escape detection and get away from its enemies.

The sheep crab is a large species that reaches a length of eight inches across the back. It is found from San Francisco to Port San Bartolomé, Baja California, down to a depth of some 400 feet. Fossil spider crabs occur in Fresno County, California, indicating that this area was covered by sea at one time.

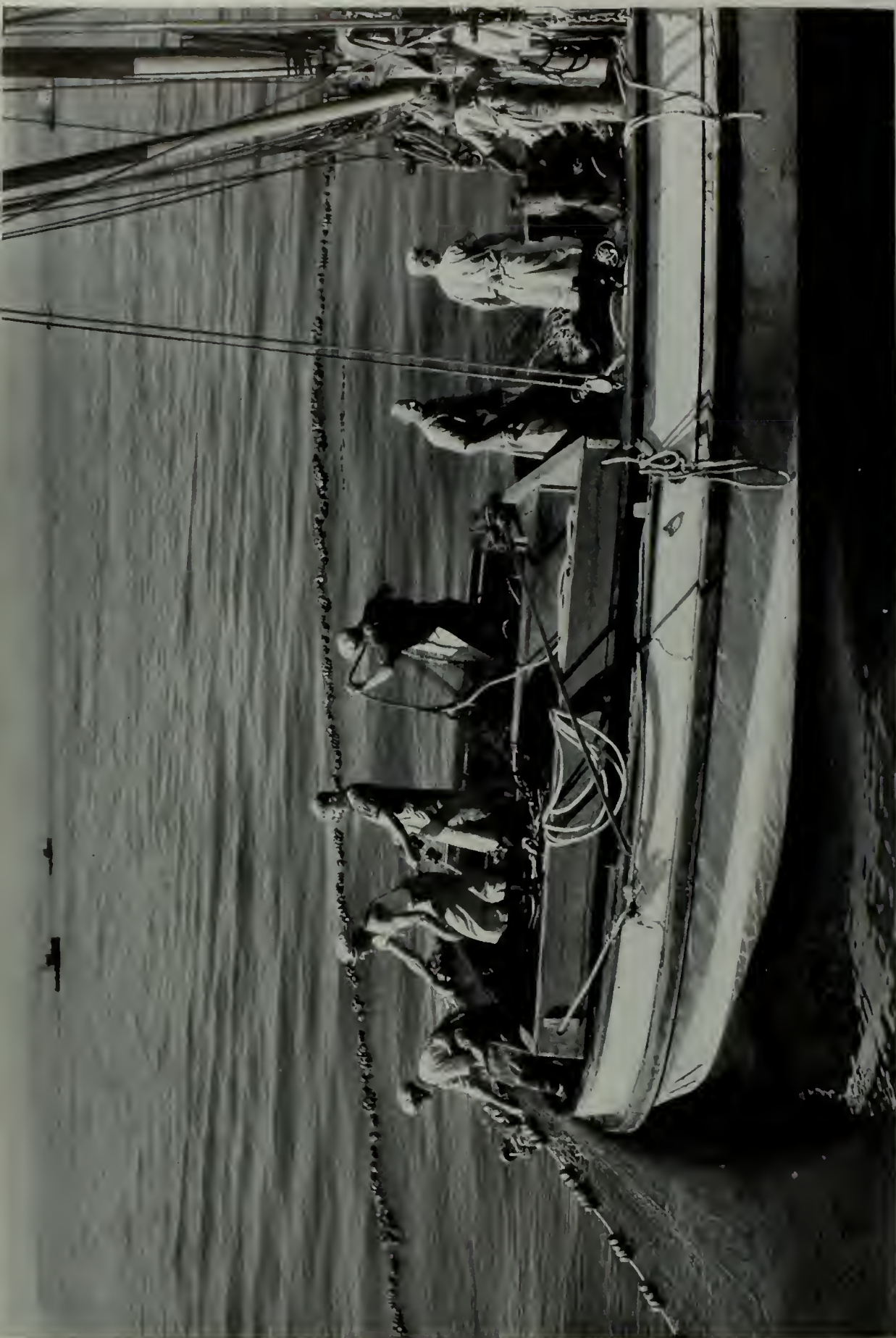
Although these long-legged crabs are abundant, their slender legs do not contain much meat compared with those of the market crab. Even those in Alaska that measure about $3\frac{1}{2}$ feet between the tips of opposite legs are not caught commercially and are used only locally.



Painting by Hashime Murayama

WITH SHOCKS FROM ITS "STORAGE BATTERIES" THE ELECTRIC RAY STUNS FOES

Mysterious organs, lodged at each side of the head and gill chambers, discharge with great power when the **Electric Ray** is stimulated by anger or fear. Sometimes three feet long, this member of the torpedo-fish family lives at the bottom of the ocean. The ludicrous **Sheep Crab** treads the kelp beds on its long legs with deliberation. On its shell back it collects barnacles, marine animals, and seaweed.



Photograph by Ewing Galloway
A 2,000-FOOT PURSE SEINE PULLED ON PUGET SOUND BANKS BECOMES A HUGE FISH BASKET WITH ONLY A TEN-FOOT OPENING AT THE TOP



IT TAKES "BEEF" TO HANDLE FISH OF THIS SIZE

An entrant in the annual salmon fishing contest held at Elliott Bay, Seattle, Washington, struggles to haul aboard with his gaff a fat 35-pound chinook. In the prize "playoff," contestants are limited to a few hours of fishing time. The angler who catches the largest fish during that period is the victor.



Photographs by Ew'na Galloway

JUST A BIT TOO BIG FOR THE FRYING PAN!

A triumphant fisherwoman displays a 32-pound chinook salmon caught with rod and reel in an inlet near Seattle, Washington. Salmon and steelhead trout abound in Puget Sound and its tributary waters. With the outboard motor throttled down, the boat moves along at proper trolling speed.



BLACK PERCH, BEARING YOUNG IN A PAIL, REVEALED THAT SURF FISH DO NOT SPAWN
Until Dr. A. C. Jackson accidentally discovered this mammal-like trait in the **Black Perch** 85 years ago, ichthyologists thought the family deposited eggs as do most other fishes.



MALE PIPEFISH INCUBATE EGGS AND REAR THE YOUNG IN A KANGAROO-LIKE BROOD POUCH

Responsibilities of the female **Pipefish** end when she deposits the eggs in her mate's sac, formed by two folds of skin. Long, narrow bodies, covered with bony rings, merge with the eel grass. The **Black-tailed Shrimp** fades into its sandy bottom home.

Pipefish

(*Syngnathus griseo-lineatus*)

Usual Length, 8 Inches

Related to the sea horses and sticklebacks, the pipefish belongs to the family Syngnathidae, members of which are found in all warm and temperate oceans of the world, usually inhabiting the shores among seaweeds. Some pipefishes have been reported to ascend rivers in China and India.

On the coral reefs of Canton, Hull, Enderbury, Swains, and Tutuila Islands of the South Pacific, I collected pipefishes. These lived in tiny holes or crevices in the coral rock and could be driven out with chemicals only. They were dark brown in color.

The color of these fishes changes to correspond with the seaweeds or rocks among which they feed, and in eelgrass they are bright to dark green. Once I found one of a dark reddish hue in a rock pool lined with dark-red coralline algae. Their bodies are covered with a series of bony plates or rings. They swim very slowly, often in an "S" shape, and the only fin movements visible are in the tips of the rays of the dorsal.

Although there are several other pipefishes along our coast, this one is the largest, reaching a length of a little more than a foot. It occurs abundantly in bays from southeastern Alaska to Monterey Bay, California.

In the third century B. C. Aristotle wrote: "That fish which is called belone, at the season of reproduction, burst asunder and in this way the ova escape; for this fish has a division beneath the stomach and bowels like the serpents called typhinae. When it has produced its ova it survives, and the wound heals up again."

That probably was the first account of the remarkable method of reproduction in the pipefishes.

The two sexes may be readily distinguished because the male has a pouch under the abdomen where the young incubate. For once Nature has made the male the nurse and evened things up a bit in caring for the babies.

When the eggs of the female fish are ready to start development into young pipefish, the two sexes come together, and after a short period of courtship the eggs, numbering well over a hundred, instead of being laid in the water, are transferred to the pouch of the male. There they soon develop into tiny embryos, later into baby pipefish, much as the baby kangaroo develops in the marsupium of its mother.

In the Puget Sound region of Washington the young pipefish escape from the pouch in June, July, or later in the summer, at a length of about an inch.

The pipefish feeds on small crustaceans, shrimplike animals, and tiny marine worms. Because of its small mouth at the end of a long

snout, it is not adapted to voracious habits and is a slow swimmer, quiet, inconspicuous, and easily overlooked. It is of no economic value, but its extraordinary methods of reproduction make it an interesting species to display in an aquarium.

Black Perch

(*Embiotoca jacksoni*)

Usual Length, 10 Inches

Not a true perch, the black perch of the surf fish family, Embiotocidae, belongs to that peculiar group of shore fishes that give birth to their young. They inhabit the North Pacific and are found nowhere else in the world. The strikingly colored black perch, which reaches a length of 14 inches, has considerable commercial value. Anglers catch it on hook and line baited with bits of clams or worms.

Among the 22 species of viviparous perch in the family, the blue perch, *Taeniotoxa lateralis*, is nearest like this species.

Breeding occurs during the summer, but the eggs do not start developing until autumn. The female has an ovary-uterus, in which the eggs are fertilized and develop into embryos between the delicate folds of tissue of this organ.

Birth occurs in the spring or early autumn. The young at birth are miniature adults, capable of taking care of themselves.

Shrimp

(*Crango nigricauda*)

Usual Length, 4 Inches

Often called by fishermen deepwater, black-tailed, and black shrimp, this is one of the most important species of shrimp in the commercial catch. It belongs to the crustacean family, Crangonidae, and may be recognized by the hands of the first pair of chelipeds, for the thumb ends in a spine and the finger folds against the margin of the hand.

This crustacean, together with its several close relatives in the region, enters into the commercial catch. It is known from Alaska to Baja California.

The chief method of capture of shrimp is the trawl, with a beam of 18 to 25 feet, fitted into an iron frame to which is attached a funnel-shaped net about 60 feet long. After being dragged over the bottom for an hour or longer, the trawl with its contents of shrimp and fish is hauled on board.

The shrimp are picked out and cast into boiling salt water for a few minutes. They are then placed in wire baskets to drain and cool off before being taken to market. The annual catch of shrimp along the Pacific coast of the United States has been from 1,500,000 to 3,000,000 pounds.

This shrimp spawns from spring to autumn, and the eggs hatch near the ocean in water of high salinity where they are probably laid. The larvae occur in the plankton, the suspended



Painting by Hashime Murayama

LEOPARD SHARKS FEED VORACIOUSLY ON OTHER FISHES BUT ARE HARMLESS TO MAN

Seldom does the **Leopard Shark** exceed five feet in length. It is not related to the great white shark, or "man-eater," that occasionally has injured bathers along the Pacific coast. Black bars across its back and upper sides distinguish it from the dangerous species. When the leopard shark becomes entangled in a sardine purse net, it can do much damage, for needlelike spines cut the twine mesh.

small living organisms in the sea, but later advanced stages are found in the shallow water of the bays.

They breed at the end of the first year of life and soon afterward are no longer caught. What happens to them is not definitely known. The adults reach a length of about 3 or 4 inches, the females being 25 per cent larger than the males.

Leopard Shark (*Triakis semifasciatus*)

Usual Length, 40 Inches

Known from San Francisco Bay to Ballenas Bay, Baja California, the leopard shark may be distinguished from other sharks in the family Galeidae by conspicuous black bars across the back and upper sides. Along the lower sides are round black spots mostly opposite and between the ends of the crossbars. It is one of the commonest species in the markets of southern California and is frequently taken on hook and line by anglers.

The male shark may be distinguished from the female by the claspers—long armlike organs extending backward from the inner edge of the pelvic fins. Claspers occur on skates, rays, and practically all species of sharks. They are used in copulation at breeding time.

The sharks, rays, and skates, taken as a whole, have been exploited in recent years on a commercial basis, because of the discovery of the many valuable uses to which they can be put, but previously they were considered as the vermin of the sea. Now there are extensive shark fisheries in Western Australia; New South Wales; Gulf of Mexico; West Indies; Monterey Bay; Djibouti, French Somaliland; and Virgin Islands.

It has been a common practice of fishermen in the past to kill the sharks caught and throw them into the sea, an act that nearly exterminated the sturgeon of the Great Lakes and those of the Columbia River some years ago. In Asiatic countries, sharks, skates, and rays play an important role as an article of diet, but in this country they are not popular.

Skate "wings" are sold in many markets on the West Coast. They are used for soup. Shark meat is hard and firm and has a sweetish taste, but it is not used so extensively here as in Europe and Asia. There is no uniformity of food quality among the different species of sharks and skates. Some may be used for food, and others are valuable only for reducing to fertilizers, fish meals, oil, and other products of the sort. The livers are especially rich in oil.

Methods of capturing sharks are varied. The hand-thrown harpoon, or lily iron, is effectively employed by experienced shark fishermen. Lines of rope, 1,500 feet long, with wire leaders at 12-foot intervals fitted with large fish-baited hooks, have proved their worth; and troll lines are used also. Most successful, how-

ever, are gill nets. These vary in length from 600 to 3,000 feet long and 18 to 24 feet deep, with a mesh about 20 inches stretched. They are set on the ocean bottom and anchored at each end. A buoy with a flag as a marker is fastened to one or both anchors.

When a big shark gets into a sardine seine, the thousands of needlelike spines acting in the skin as an abrasive so weaken the twine of the net by movements and contact with it that the net is nearly ruined. Often it takes a half day of heaving and cutting to remove a big basking shark that has blundered into a purse seine; and the cost of repairs may amount to a thousand dollars or more.

The sharks captured in the commercial fishery are skinned and the hide is manufactured into leather. In the past shark skins were used only as an abrasive for polishing. This was possible because the skin is covered with shagreen, or placoid scales, which when examined under a microscope are revealed as small spines. The tanned shark leather is used for shoes, pocket books, traveling and handbags.

In sharks and skates there are two common types of reproduction. Most sharks give birth to a few young much as in rockfish, guppies, and the surf fishes. In the skates the female deposits egg cases which contain developing embryos, somewhat similar to birds; the egg cases, however, are horny, box-shaped structures, a few inches in length with long tendrils at the corners which fasten themselves to sea weeds or rocks, much as the tendrils on a grapevine hold it to a tree.

Most sharks are voracious creatures, feeding on other fishes. Their jaws are lined with several rows of sharp, more or less triangular-shaped teeth, capable of biting a chunk of flesh out of almost any fish. Very few sharks are harmful or dangerous to man. The great white shark, or man-eater, and some close relatives of it have made fatal attacks but those are so few and rare along our shores that a bather is more liable to be struck by lightning.

Some species of sharks are not voracious but harmless even to fishes, feeding only on small plankton (the small, nearly microscopic plants and animals that float in the sea). These are strained out of the water by means of sieve-like gill-rakers, such as those in the basking shark and in the whale shark. These two are the largest species of living fishes known. They reach a length of 45 feet. Of course whales attain a greater size but they belong to another group of vertebrates, the mammals, and are not true fish.

A fish such as a shark measuring 45 feet in length would weigh, according to data recently accumulated, approximately 44,000 pounds.

The leopard shark in west coastal waters is a small species that does not reach a length of much more than five feet. It feeds mostly on fish and is perfectly harmless to man.



Painting by Hashime Murayama

COCK-EYED PLATFISH AND FISH-EATING CRABS WITH SAND FILTERS SKULK ON THE PACIFIC FLOOR

When hatched, the **Starry Flounder** (lower) and the **Mottled Sand Dab** (right) swim normally. As they grow, they lean more and more on one side until their position is horizontal. Gradually the skull twists and one eye migrates close to the other until both are on the same side of the body. Blotches on this "eyed" or "top," side soon harmonize with the sea floor, while the "bellies" become silvery white. The **Market Crab** lives in the sand. Teeth along the shell edge keep coarse granules out of the gills.

Starry Flounder*(Platichthys stellatus)*

Usual Length, 14 Inches

The starry flounder, a characteristic flatfish of the Pacific coast, belongs to the family Pleuronectidae. It may be distinguished from all other flounders by the rough star-shaped scales on the eyed side and the several black bars on the fins. This species is the commonest one along the beaches in the sand of the United States and occurs from Japan to Alaska and southward to Santa Barbara County, California. Along our coast as far north as southeastern Alaska about one half have the eyes and color on the right side and the other half on the left side.

In False Bay, San Juan Islands, Washington, the author found starry flounders abundant in the shallow water at low tide. They were partly buried in the sand, and he had no difficulty in capturing enough for a big dinner by the simple expedient of slipping up and stepping on them.

The starry flounder, taken commercially throughout most of its range, makes up less than ten per cent of the 9 to 12 million pounds of "sole" and flounder caught annually in Washington, Oregon, and California. In the latter State alone the average catch of starry flounder for three years has been 741,687 as against 8,597,016 pounds of "sole." The fish reaches a length of nearly three feet and a weight of 25 pounds.

In the Puget Sound region this species attains sexual maturity in its third year and spawns in February, March, and April. The eggs and larvae are pelagic, floating suspended in the water.

The food of the starry flounder consists mainly of worms, crustaceans, and small fish. Often the necks of clams, which have been bitten off as they protruded out of the sand, appear in the flounders' stomachs.

Mottled Sand Dab*(Citharichthys sordidus)*

Usual Length, 11 Inches

The mottled sand dab belongs to the family Bothidae. Members of the family resemble the flounders, but may be distinguished from them because one of the pelvic fins is on the median ridge of the abdomen, the color is on the left side, and the scales are rather large.

The mottled sand dab occurs from Kiska Island (Aleutian chain), Alaska, southward to Cedros Island, Baja California. From British Columbia southward it abounds in water of moderate depth, often being taken commercially in trawls at 240 feet. It inhabits sandy and muddy bottoms, feeding on small organisms, including shrimp and worms.

Recent research on this species by Richard T. Smith of Seattle indicates that it first spawns when about two years of age. The

spawning period is during March and April in the Puget Sound region. The females, larger than the males, reach a length of more than 15 inches and a weight of about two pounds.

Market Crab*(Cancer magister)*

Usual Length, 8 Inches

The market crab, belonging to the crustacean family Cancridae, is closely related to lobsters, shrimp and crayfish. Of the same family are several other smaller species of crabs of little commercial value, but the market crab has been caught along our coast since its earliest settlement.

The market crab is one of the biggest crabs along the Pacific coast. The carapace is well supplied with teeth or denticles. The color of its upper surface is a light reddish brown. Its large claws and legs and the ventral surface are of a yellowish color.

Although this crab normally inhabits sandy bottoms below the tidal zone, sometimes young *Cancer magister* will be found above it in sandy pools. It shows a distinct preference for sandy bottoms, but is frequently found on the mud of bays, never on rocky shores. For most of the time the crabs lie partly buried in the sand and are equipped with a straining apparatus that keep fine particles out of their gills.

Cancer magister is found from Unalaska Island, Alaska, to Magdalena Bay, Baja California, but is common only at Monterey Bay and northward. It lives on sandy bottoms to a depth of 60 feet, and reaches a length of eight inches, measured across the back. The females, protected by law, can be distinguished from the males because their abdomens are broader. The maximum weight is about three pounds.

Along the Pacific coast of the United States the commercial crab catch averages about five million pounds annually. Equipment has varied, but the hoop net is still used in the northern area, the Monterey Bay crab net (adapted from the sea bass gill net) in southern waters.

When placed together in the boats, the crabs go after one another furiously, but only legs are lost. These would soon regenerate if the creatures were permitted to go free.

The market crab often has an encrustation of barnacles and other marine growths on its carapace which makes it less attractive on the market. By the use of a brush with steel bristles, the crab usually can be cleaned and made marketable. Sometimes, after cooking, the back of the crab, instead of being red, shows blackish areas which were caused by injuries. These superficial injuries in no way affect the food value of the crab.

Dr. F. W. Weymouth has observed that in moulting, the weight of the emerging crab, that is, the weight of the hard crab less the weight of the cast shell, may be doubled within



Painting by Hashime Murayama

GIANT OCEAN SUNFISH BASK LAZILY NEAR THE SURFACE OF THE OPEN SEA

Big fellows, when fully grown, may measure fourteen feet and weigh two tons. **Ocean Sunfish** (young, upper pair) have thick, rough, leathery skins and are not edible, although the Japanese consider the liver a delicacy. Tiny suckfish use the monster's gill cavities as homes. Flesh of the smaller **Opah** or **Moonfish** (adult, lower foreground) is tender, rich, and oily.

an hour. The extra weight is the result of absorption of water into the blood. Before moulting, the volume of blood may be but 5 per cent of the body weight; soon after moulting it may be 50 per cent. Thus, since only a small amount of the blood is coagulated by boiling as much as half of the original weight of the crab may be lost as water. Usually these freshly moulted crabs are called "empty" because when the cooked specimen is opened there is little to be seen in the shell except stomach, liver, and hard parts. Experienced fishermen do not bring such crabs to the market.

The crabs have well developed eyes, but these probably are of minor importance in their feeding habits. The exhalant current from the gills constantly bathes the antennules which inform the crab of his immediate surroundings. Thus currents, bearing the meat juices from bait, pass by the antennules, and the crab is directed to the food. The market crab is exclusively carnivorous; stomach contents show fish, shrimp, and small crabs to be the chief items eaten.

Ocean Sunfish

(*Mola mola*)

Usual Length, 40 Inches

To a group of specialized fishes called headfishes, family Molidae, belongs the ocean sunfish. The one illustrated on the opposite page occurs in all temperate and tropical seas of the Atlantic and Pacific Oceans and along the Pacific coast of North America from southeastern Alaska southward. They are fish of the high seas, but venture close into shore.

Often ocean sunfish, floating at the surface as if asleep, make excellent rifle targets. Two observers who watched several two or three feet long swimming at a depth of a fathom in Monterey Bay, report:

"The swimming appears to be accomplished almost exclusively by the lateral sculling movements of the dorsal and anal fins, although body movements may assist. The fish were more active than their ungainly form would seem to permit, easily avoiding oars with which we attempted to touch them. A number were seen to leap into the air, at least one entirely clearing the surface."

The peculiar shape, all head and practically no tail, accounts for the name "headfish," and the habit of lying at the surface almost motionless resulted in the name "ocean sunfish."

Occasionally large specimens are found. One mounted in the American Museum of Natural History, New York City, measuring 10 feet in length by 11 feet vertically, was taken off southern California in 1910, another from near Los Angeles, caught 1893, as reported by Dr. Gudger was 8 feet 2 inches "overall" and weighed 1800 pounds. One mounted in the United States National Museum, Washington,

D. C., measures 6½ feet in length and 9½ feet vertically. Because of their peculiar shape these huge specimens make excellent displays.

Dr. Gudger, in his account of the "Capture of an Ocean Sunfish" in the *Scientific Monthly*, quotes the following from *The Wide World Magazine* for December 10, 1910:

"When the *Fiona* . . . was off Bird Island, about forty miles north of Sydney Heads on her way from Clarence River to Sydney, a little after 1 P. M., all hands were alarmed by a sudden shock as though the steamer had struck a solid substance or wreckage. The result was strange and remarkable, for the port engine was brought up 'all standing.' The starboard engine was quickly stopped and a boat lowered and sent to investigate.

"On getting under the steamer's counter, the boat's crew were astonished to find that a huge sunfish had become securely fixed in the bracket of the port propeller. One blade was completely embedded in the creature's flesh, jamming the monster firmly against the stem-post of the vessel.

"It was impossible to extricate the fish at sea; so the boat was hoisted on board again and the steamer proceeded on her passage to Sydney with only the starboard engine working. . . . After much difficulty, and with the aid of the steamer's winch, the sunfish was hoisted clear and swung on board. The *Fiona* then proceeded to the Sugar Company's wharf. The fish was put on the company's weighbridge, and found to weigh two tons four hundred-weights (4,400 pounds). The measurements were: Length, ten feet; across the body, six feet; across the body and fins, fourteen feet. . . ."

A photograph of the fish with bystanders verifies the incident.

Although ocean sunfish reach a large size, they are harmless creatures, feeding on various forms of invertebrate life, and are of practically no commercial value.

Opah or Moonfish

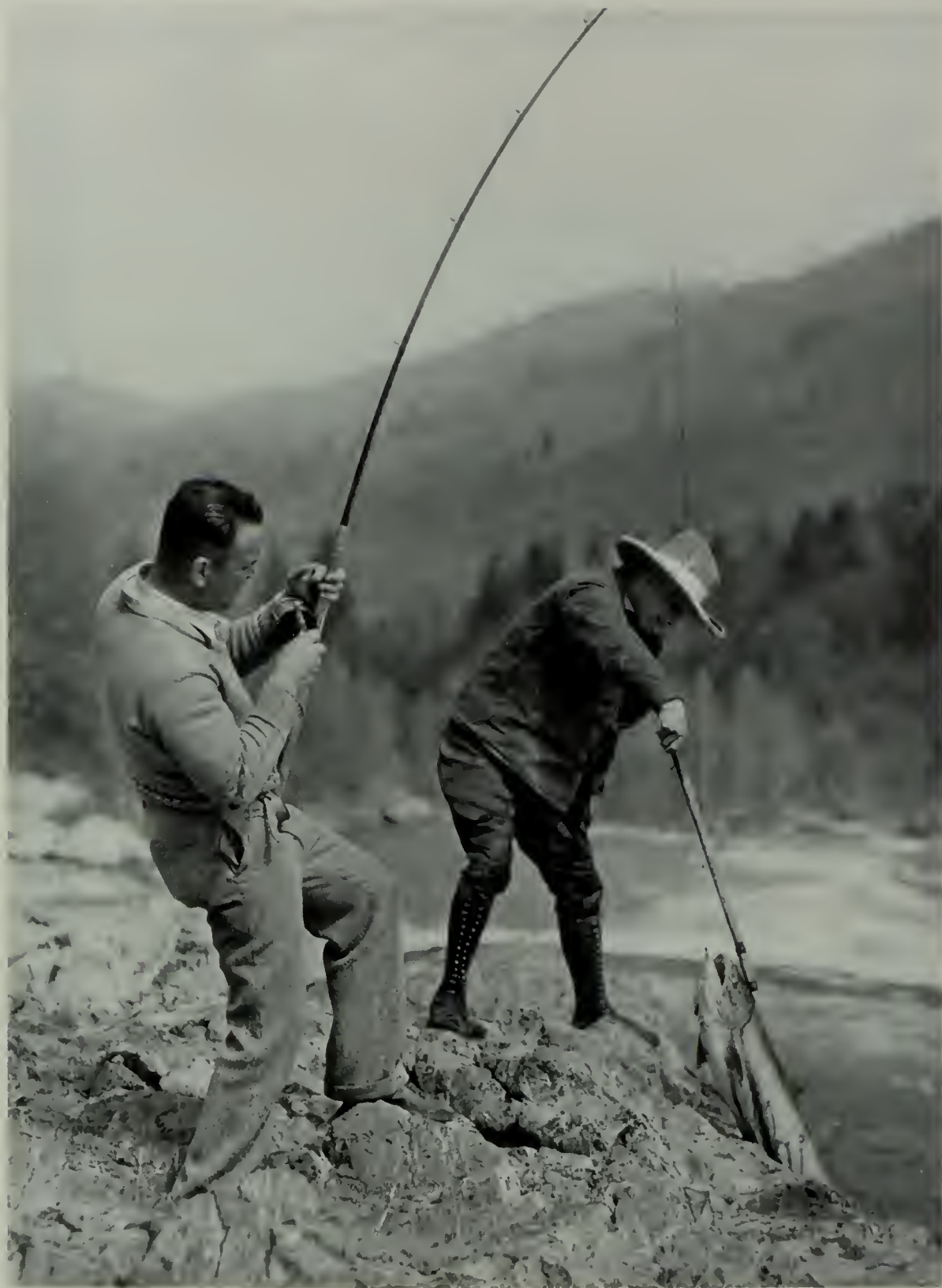
(*Lampris regius*)

Usual Length, 30 Inches

The opah, or moonfish, one of the most beautiful and graceful fishes in the ocean, belongs to the family Lampridae. It has been reported singly and in schools in the open seas in widely scattered areas of the Atlantic and Pacific Oceans, and along our Pacific coast it has been taken as far northward as off Yakutat, Alaska.

There is a single living species which reaches a length of about six feet and a weight of 600 pounds. The flesh is described as salmon-red, tender and oily, with a delicious flavor.

Although desirable as food, the moonfish has no economic importance. Because of scarcity and irregular occurrence, it is not sought commercially on the Pacific coast.



TO THE SONG OF THE SINGING REEL, THE ROGUE RIVER PLAYS LIVELY ACCOMPANIMENT

Oregon still has vast, unspoiled wilderness areas where, in rushing mountain streams, several kinds of gamy trout take the lure greedily. Fishing in these rollicking waters, the angler needs only a single catch such as this big steelhead to make a day's sport worthwhile.

FISHING IN PACIFIC COAST STREAMS

Hatcheries, Stream Improvement, and Fish Ladders Assure the Future of Sporty Trouts and Highly Valued Salmons

BY LEONARD P. SCHULTZ

Curator of Fishes, United States National Museum

MY EARLY fishing experience was confined to sitting on a railroad bridge and coaxing sunfish, rock bass, and catfish to take a hook baited with angleworms, or going with my father to a lake and angling from a boat for bluegills and yellow perch in southern Michigan. Now, after summers in Glacier and Yellowstone National Parks, and several years on the Pacific coast, I am converted into an enthusiastic fly fisherman.

Unlike many fishermen, I did not limit my interests to the trout, but sought all the other species of fresh-water fishes that occur in western North America. A few of these are discussed in this article.

NO FUR ON FISHES

In Glacier National Park I did not find the celebrated fur-clad trout that old-timers describe to gullible tenderfeet. Fish do not grow fur, despite the rumors; they are, however, provided with scales, spines, plates, naked skin, and prickles. Some, such as catfishes and sturgeon, have "whiskers," but these are long fleshy barbels, without the slightest resemblance to a hair.

When trout have not responded to artificial lures, I have searched the submerged rocks, logs, and vegetation for natural fish foods. The tiny clams that live in the mud or sand bottoms of lakes and streams are not readily taken by trout. However, crustaceans, such as the fresh-water shrimp, amphipods, and crayfish, as well as aquatic insect nymphs or larvae of stone flies, May flies, caddis flies, and worms, make excellent bait. Land insects, especially grasshoppers, are attractive, too, causing trout to strike when they refuse artificial bait.

The salmon and trout of western North America, family Salmonidae, are of the greatest interest to sportsmen, fishermen, and scientists, not only for their recreational and economic value, but for their grace, beauty, and absorbing life stories. To maintain the supply of these species, the several States and the United States

Bureau of Fisheries artificially propagate each year many millions and distribute the eggs, fry, and young fish to the streams and lakes, in some cases dropping them from airplanes.

In addition to this restocking, some streams in western national forests and parks have been improved by the establishment of environments attractive to trout. Covers or shelters have been built, and current deflectors have been made of stones, logs, and brush, causing pools to form. In streams with soft sand bottoms little food grows, but on gravel or rubble much develops, so that devices to remove the sand and expose the gravel greatly improve trout and salmon habitats.

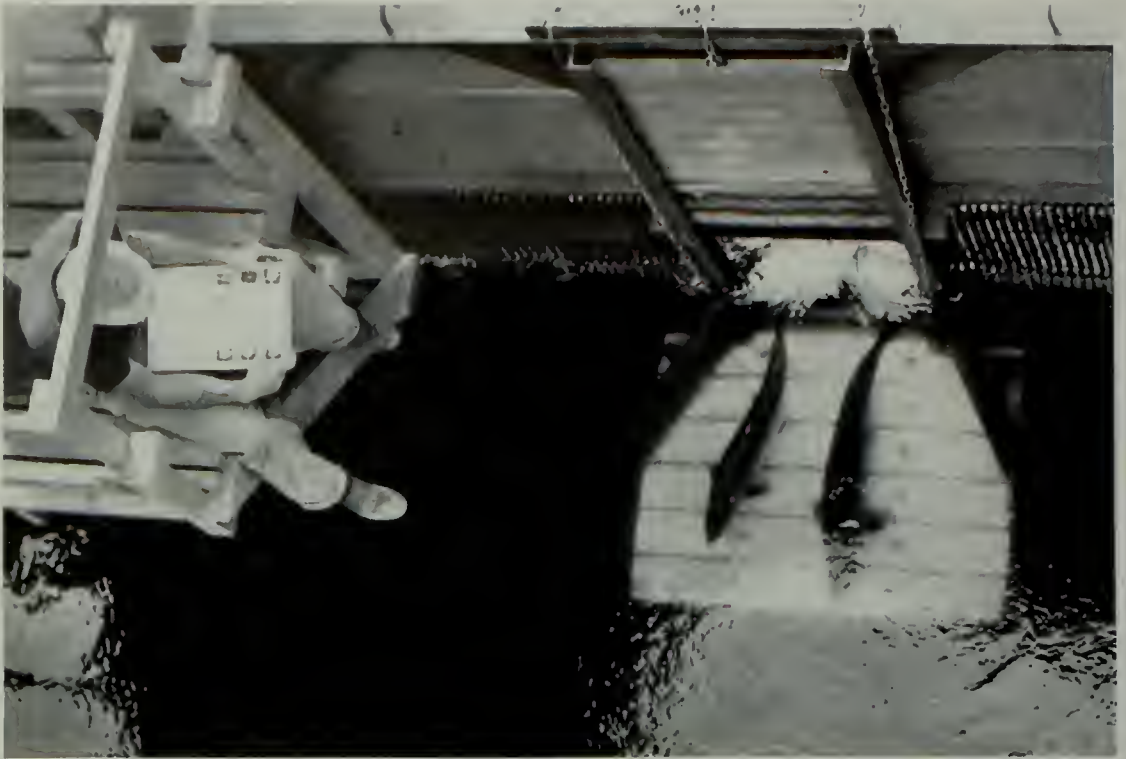
Clearing streams of snags and brush or straightening them to enhance their beauty is a mistake from the fisherman's viewpoint. Such changes remove the natural shelters for fish and for the production of fish foods.

Salmon fisheries extend from Monterey Bay, California, to the Yukon River in Alaska, and westward to Kamchatka and northern Japan. In North America alone the average annual pack of canned salmon exceeds nine million cases (48 one-pound cans to the case); and usually more than four-fifths of this is canned in Alaska.

The total market value of fresh and canned salmon caught in North American waters in the last decade goes beyond a half billion dollars. This tremendous fishery, which took nearly eight billion pounds from 1927 to 1936 and gave employment to thousands, is confined to five species of Pacific salmon (Color Plates, pages 284, 286, 288, and 290).

CHINOOK A BETTER NAME FOR SALMON

The name "salmon" was first used in Europe for the Atlantic salmon (*Salmo salar*), closely related to the steelhead trout of the Pacific coast (Color Plate, page 273). Unfortunately the term "salmon" was applied to these fish of the Pacific, when the local Indian name "chinook" would have avoided



Photograph by W. D. Staats

CENSUS TAKERS COUNT FISH AS THEY REACH THE TOP OF THE "WATER STAIRS"

A submerged white platform shows up weary salmon as they cross the upper "landing" of a Bonneville Dam fishway. During the first six months' actual count, almost half a million salmon and steelhead trout passed the dam on the way up the Columbia River (page 265).

confusion with the wholly different Atlantic salmon.

The spawning migration of salmon is anadromous, or from the sea to fresh-water streams. This is the reverse of that of fresh-water eels, *Anguilla*, which have a catadromous migration, or from fresh-water streams to the sea. In the Yukon River the late Dr. C. H. Gilbert discovered that some chinook or king salmon go upstream about 3,000 miles. Their migration is probably longer than that of any other species of salmon or trout. The pink salmon migrates least of all Pacific salmon; it spawns only a few miles above salt water.

In trout, *Salmo*, and charrs, *Salvelinus*, the migratory instinct is definitely developed, but these forms pass most or all of their lives in fresh water, and thus there is no necessity for their migrating so far.

The salmon, in their urge to reach the proper place to deposit their eggs, often wear themselves out trying to navigate waterfalls or fish ladders placed in dams. Pacific salmon will jump vertically four times their length or more.

Sometimes they are killed by falling backward and striking sharp rocks. If not

seriously injured, they continue to leap until they either go over the obstruction or drift exhausted downstream to fall prey to birds, bears, or other predators. By the time they have spawned, both salmon and trout are weakened and often emaciated.

This worn-out condition is not, however, the chief cause of the death after spawning of the five species of Pacific salmon. They have reached the end of their life cycle, and even fish in good condition die soon after their reproductive period is completed. Trout, steelhead, and charrs may spawn for several successive years.

LIVE FISH RELATED TO FOSSILS

One remarkable trait of salmon is their "homing instinct," their mysterious ability to return to the stream in which they developed as fry and fingerlings. When eggs have been taken from females in one river and transferred to another stream for development, the young produced have gone through their life cycle and returned to spawn in the waters where they were hatched rather than in the habitat of their parents. Returning of tagged or marked fish and study of their scales have proved



Official Photograph U. S. Army Air Corps

COSTLY "ESCALATORS" HELP SALMON PASS HUGE BONNEVILLE DAM

Because blocking of the Columbia River threatened to cut off fish from their spawning grounds upstream, United States Army engineers, assisted by biologists, planned this system of fishways and fish elevators which cost more than \$6,500,000. There are three main "ladders," up which the salmon can swim and jump. Cross walls divide these flumes into foot-high "steps," each 40 feet wide and 16 feet long. Two of the fishways curve up on Bradford Island, one from the foot of each dam, and unite, halfway, to continue as a single passage (center). A third ladder encircles the end of the dam (bottom). Powerhouse and ship lock are seen above.



Photograph by H. S. Lawton

"GEE! WHAT DID YOU USE FOR BAIT?"

A few minutes before posing unawares in this scene of rural boyhood, the big trout was swimming in swift waters of the Feather River in the Sierra Nevada of California. The prize is a brown trout, native to Europe, but now introduced widely throughout the United States.

that most salmon return to their "home stream."

The Alaskan blackfish, a close relative of the Washington mud minnow, lives in the coastal tundra regions of Alaska in ponds and streams. It is barely distinguishable from a similar form living across the Bering Sea in Asia.

The Washington mud minnow, *Novumbra*, which would make an excellent aquarium fish, is found only in the Chehalis River of western Washington. It has, besides the Alaskan blackfish, two relatives in eastern North America and one in Europe. No doubt the mud minnows are relics of a fish fauna that once occupied much of the Northern Hemisphere.

Abundant fossil fish remains have been found in the Miocene deposits or diatom beds at Lompoc, Santa Barbara County, California. These deposits contain forms such as the herrings, flatfish, top minnows (cyprinodonts), and many species of spiny-rayed bony fishes.

Other formations, such as those at Soladad Pass, Los Angeles County, and the Eocene Green River shales of Wyoming, contain a wealth of ancient relics. Much of the present fish fauna of the West was derived from forms that lived in past geological periods and are found fossilized in the above-mentioned deposits.

SOME LAMPREYS ARE BLOODSUCKERS OF THE FISH WORLD

The lampreys of the western streams are of two types, the nonparasitic brook lamprey and the parasitic lake and sea-run lampreys. The latter, which reach a length of nearly three feet, migrate up the coastal streams in late spring and early summer for spawning in gravel riffles.

These lampreys excavate saucer-shaped nests by picking up stones in their suction mouths and carrying them a few feet away. The tiny white eggs, deposited in the bottom of the nests, hatch in about two weeks, and the little grayish larvae work their way into the sand and soft mud with only the mouths projecting. Blind and without teeth, they remain there for about three years, feeding on the minute plant and animal organisms that drift near their funnel-shaped mouths.

After metamorphosis, at which time teeth form and eyes appear, they migrate down to the sea and then become parasitic on fishes. They rasp off the skin of their luck-

less victim with their sharp teeth and suck its blood. I have found the tooth marks of this lamprey in the skin of the opah, or moonfish (*Lampris regius*).

The fresh-water sculpins, or bullheads as they are known in the West, are common little fishes of the streams and lakes. Some species are found only among stones in rapidly flowing water. My favorite way of collecting them is to place a 6-foot seine on the rifle and vigorously kick the stones about, allowing the swift water to carry my prey into the net. Sometimes the long-nosed dace and tadpoles of the tailed frog *Ascaphus* also are swept into the net.

DIFFERENT SPECIES MAY INHABIT NEIGHBORING WATERS

The faunas of the Pacific coastal drainage systems have much in common, yet the species differ among the river systems and lake basins.

Fish of the isolated lakes of southeastern Oregon and of the Lake Lahontan Basin are distinctive. Some forms found in the Columbia River are represented by similar forms in the Sacramento-San Joaquin system, but in both rivers are species found nowhere else.

The fish fauna of the Great Salt Lake drainage system is characteristically that of the Snake River, a tributary of the Columbia. That of the Fraser River is similar to that of the Columbia, too.

In none of the streams west of the Continental Divide in the United States occur endemically such species as the paddlefish, the bowfin, the pirate perches, pickerel, the gar pike, darters, and yellow perch. But such fish as the cyprinids (minnows and dace), centrarchids (basses and sunfish), the ling, sculpins, trout, and whitefish, are found on both sides of the Divide.

Among the fresh-water fishes of the Pacific coastal streams are to be found the largest minnow in North America, the squawfish (Color Plate, page 278), and the largest anadromous fish, the white sturgeon (Color Plate, page 280).

In the Sacramento-San Joaquin drainage system occur 40 endemic species, as contrasted with 46 in the Columbia system, 15 of which are common to both streams. In addition to the endemic forms, 18 species have been successfully introduced into the Columbia and 19 into the Sacramento-San Joaquin, 17 of which are reported from both stream systems.

South Fork Golden Trout

(*Salmo agua-bonita*)

Usual Length, 8 Inches

The golden trout of California was named for Agua Bonita Falls (now Volcano Falls) in Volcano Creek (now Golden Trout Creek) under the supposition that the first specimens came from there. Actually, however, the species was found originally only in the headwaters of the South Fork of the Kern River, south of Mount Whitney, a high mountain area to which it was confined by impassable falls.

Usually less than 10 inches long, it belongs to the rainbow series of trout, lacking the "cutthroat" marks, a pair of red color bars, one on each side of the underpart of the head along the inner edge of the lower jawbones.

These beautifully colored mountain trout, which occur in pools and rapids, may be taken in any sort of weather with artificial flies or on hooks baited with insects. During mid-day they frequent the deeper pools, lying in the shadows of overhanging rocks. They feed on aquatic insects, worms, and flying insects that alight on the stream. Aquatic caddis-fly larvae and midges make up more than 80 per cent of their diet.

Trout as a group have been caught by sportsmen since America was first settled, and almost from the beginning methods have been used to maintain or build up the supply of game fish.

The introduction of exotic species to improve fishing was first employed, with marked success in some cases and in others the foreign fishes have driven out the more desirable species of trout.

As conditions changed and civilization advanced, there was passed to protect the trout, legislation such as bag limits, size limits, and closed seasons. Along with the protective legislation, fish culture was introduced and serious attempts were made to restock the heavily fished waters.

Recently it was realized by those interested in angling that our fishing ills could not be cured by past methods; consequently there has grown up in this country much enthusiasm in what is called *lake and stream improvement*. This movement is directed at fish-habitat improvements, such as reforestation and the installation of shelters, dams, and current deflectors.

Carl L. Hubbs and Clarence M. Tarzwell are among the leaders in stream improvement in this country. By their careful study of the essential environmental factors necessary for good fish production, modern stream improvement was well underway. In the early stages of stream improvement, only pools and shelters were considered, but now the environmental improvement consists of the creation, maintenance, and development of such factors as are essential to the growth, reproduction, and

well being of the desirable game fish in the stream selected for attention.

Those factors most important for the suitable production of fish are: suitable water supply; adequate spawning conditions for the desirable species; sufficient and proper food for all age classes; suitable resting places and shelter for all age classes of wanted species.

The water must contain the necessary fertilizing materials essential for the production of fish foods, and the temperature variation must not be beyond the limits tolerated by the species to be encouraged. For trout, the temperature should be cold enough to prevent survival of predator fishes, and to hold diseases in check. The water levels of the streams should not fluctuate so much as to expose trout breeding grounds to drying conditions when eggs or fry are present in them.

Spawning areas for desirable species should be developed as well as for those species which serve as food for the trout.

Food is a very important factor in the production of trout. There should be an abundance of food for the adults as well as various types of food suitable for all sizes of the young fish. In addition there must be available an environment suitable for the growth of large quantities of organisms which make up the diet of those creatures serving as food for the trout. Thus, careful consideration must be given to the establishment of a balanced food cycle.

An abundance of shelter for all sizes of trout must be maintained to protect the young as well as the adults from their enemies. These shelters should be established too for the organisms that help make up the food cycle for trout.

Piute Trout

(*Salmo seleniris*)

Usual Length, 8 Inches

This form of the cutthroat trout—length not more than 10 inches—was found originally only east of the Sierra Divide in the small streams of Fish Valley, at the headwaters of Silver King Creek, California, above Llewellyn Falls. It differs from other cutthroats in the absence of the black spots on the body and the retention to maturity of parr marks—vertical blackish bars on the sides.

The fish readily take any kind of fly, almost irrespective of season or natural food present. They strike hard and like other cutthroats, do most of their fighting under water. They also take hooks baited with pieces of grasshopper and other insects.

To reach this remarkable trout, a leftover stock of ancient Lake Lahontan, which covered a large area in what is now Nevada, the traveler must journey 14 miles by horse or on foot from the nearest motor road. Perhaps its inaccessibility explains why it is found today in its original form, unmixed with other kinds.



Painting by Hashime Murayama

HIGH AMONG SIERRA SNOWS THEY DART AND WHIRL AND SPARKLE

Native only in a few small streams of Fish Valley, in Alpine County, eastern California, the graceful **Piute Trout** (upper pair) lacks the black spots characteristic of most trout. The glittering **South Fork Golden Trout** (lower pair) was originally found only in icy mile-and-a-half-high waters of Kern River, near Mount Whitney, California. Like the Piute, it retains the parr markings, or dark daubs, to maturity.

Coastal Cutthroat Trout

(*Salmo clarkii*)

Usual Length, 12 Inches

The coastal cutthroat trout, family Salmonidae, is common in coastal streams and lakes from Alaska to northern California. In the Columbia River Basin in Idaho and in the northern Rocky Mountain States it is replaced by a close relative, the Yellowstone, or Montana black-spotted, trout, *Salmo lewisi*. Some coastal cutthroats which have migrated to salt water and grown to large size are called locally "steelhead cutthroats."

In clear, cold mountain streams this trout is abundant, hiding among the rocks in riffles, in deep pools, under logs, and beneath overhanging bushes. During early spring it migrates into smaller streams, and when breeding grounds are reached male and female pair off over gravel riffles.

The female excavates a nest two or three inches deep by turning over on her side and vigorously flexing her tail against the bottom, the motion carrying her a little upstream and loosening some sand and gravel. The material disturbed is carried downstream by the swift current, the smaller particles farthest and the larger stones only a few inches.

After some courtship activities the eggs are laid and fertilized, whereupon the female immediately covers them with gravel by digging with her tail at the upper edge of the nest. Seepage of water among the small stones of the nest bottom supplies ample oxygen for the development of the baby trout. In from three to six weeks the eggs hatch, the period in warm streams being shorter than in cold.

A week or more after hatching, and when the yolk, or the food stored in the egg, has been nearly used up, the little light-brown trout make their way up through the gravel into the stream and soon begin to feed on minute organisms on the stones and in the water.

Stomachs of cutthroat trout show that these fish in general eat whatever they can obtain—aquatic insects such as May flies, stone flies, caddis flies, midges, black flies, and their nymphs or larvae; land insects which fall into the stream; such fresh-water crustaceans as crayfish, fresh-water shrimp (amphipods), fairy shrimp, and water fleas; and fish eggs, mostly those of salmon and trout.

Cutthroats rise to the fly during the warmer seasons, or will take a small spinner. In spring a fly cast over a deep pool, near an overhanging bank, or among eddies in rapids, is almost certain to be struck. The gamy fish does most of its fighting below the surface and it puts up a lively battle.

In most small streams the average size is from 7 to 12 inches, but sometimes in large streams and in lakes an 8-pounder is taken. The record is about 12½ pounds. The largest cutthroats feed almost wholly on small fishes.

Associated with the cutthroat trout in the coastal streams are whitefish *Prosopium williamsonii*, which are said to feed upon the eggs of spawning trout. No doubt the eggs, eaten by whitefish, and *Cottus*, several species of which occur in trout waters, would not have hatched anyway, for they were swept from the trout nests during the breeding activities of the trout and were picked up in the pools below the trout nests. Also there are suckers, *Catostomus*; dace, *Rhinichthys*, and other Cyprinids, but these seldom feed on trout eggs.

From the stomach of a 3-inch silver salmon, I removed 22 trout eggs, and I have also taken trout eggs from young cutthroat trout in the vicinity of nests.

The squawfish, our most voracious minnow or Cyprinid, fortunately does not occur in sufficient numbers on trout breeding grounds to be a factor in the destruction of the eggs. However, when the young trout get into deep pools or into lakes, the squawfish, *Ptychocheilus*, takes a heavy toll, destroying many young trout.

Stream improvement has been applied to the waters inhabited by cutthroat trout, mostly in the form of reforestation; forest fire protection, prohibition of overgrazing, pollution from cities, mining, and the paper pulp industries; control of erosion; and limitation of the amount of water used for irrigation and power projects.

Deforestation, forest fires, and overgrazing have often resulted in severe erosion, carrying much silt into streams and burying the food organisms essential to the trout. Irrigation and the lowering of stream and lake levels by various uses of water often result in the destruction of developing eggs and fry in the nests of trout, as well as in reduction of the area of food production for trout and forage fishes. Floods, resulting from deforestation and fires, often sweep the young fish out of the streams into pools that dry up later.

The common practice of straightening streams and cleaning out debris from lakes and streams reacts unfavorably to good fish production.

Careful planning of the improvement work for each lake and stream is essential, for no standardized method can be effective in waters with variable conditions. In waters where weed beds or brush are so lacking that only a few young fish can survive, more shelter is obviously needed.

Although stream and lake improvement may greatly increase fish production, it has inherent limitations and no degree of physical improvement can greatly alter the fish crop when the fertility is too low.

In certain small lakes it is possible to add the chemicals essential to plant and animal growth, just as farmers fertilize their crops, but where there is a great run off of water the results may not justify the expense.



Painting by Hashime Murayama

TWO RED STREAKS ON THE LOWER JAW WON FOR THIS COMMON WESTERN TROUT THE UNMERITED NAME "CUTTHROAT"

From Alaska to northern California, in every suitable river and lake of the area adjacent to the Pacific, is found the **Coastal Cutthroat Trout**. A popular prize of anglers, it is abundant in clear, cold mountain streams, hiding behind rocks in riffles, in deep pools, and under logs and overhanging bushes. When the species runs to the sea, it is called a **Cutthroat Steelhead**.

Rainbow Trout, Steelhead Trout

(*Salmo gairdnerii*)

Usual Length, 12 Inches

Most-sought game fish in the western United States are the rainbows or steelheads of the Pacific coastal streams.

The rainbow trout of the Atlantic drainage system was transplanted from our western waters, first from certain streams flowing down off Mount Shasta in northern California, but later from Oregon and Washington. Now the several breeds are so thoroughly intermixed that ichthyologists no longer can detect the anatomical characteristics of the race from the Mount Shasta region.

Commencing in the early eighties, the original stock of a form known as *Salmo gairdnerii shasta* was widely distributed from the government hatchery on McCloud River south of Mount Shasta.

Additional forms of the rainbow have received names. In British Columbia, Kamloops Lake and the adjoining region is occupied by *Salmo gairdnerii kamloops*, while the form that migrates freely to the sea, known as the steelhead, is usually called by the scientific name, *Salmo gairdnerii gairdnerii*. The name *gairdnerii*, being older, replaces the name *irideus* so often used in connection with rainbow trout.

The introduction of the rainbow trout in eastern States provided a substitute for the brook trout in many waters which had become unsuitable for that species as a result of advancing civilization. The rainbow trout can endure warmer waters than the brook trout and live farther downstream. It does not require spring-fed streams for spawning.

In the Great Lakes region, where rainbows have been introduced extensively, they are the most migratory of the trout, and drop downstream into the large lakes, where they live and grow rapidly, returning where possible to the stream for spawning. These rainbows then have adopted the migratory habits of the steelhead of the Pacific coastal streams.

The difference between a steelhead and a rainbow is principally in habit, since there is but one species. The steelhead lives and grows to a large size in salt water and then returns to the fresh-water streams to spawn. It has a steel-blue or gray back and silvery sides. The rainbow does not go to sea at all. With its broad, iridescent, reddish band along the side, the rainbow trout is well named.

The spawning migration of steelheads usually occurs in late summer, autumn, or winter, the eggs being deposited in saucer-shaped nests in the gravel riffles of streams. While the rainbow trout is a late winter or early springtime spawner on the Pacific slope, depositing its eggs from January to May, it has in its eastern habitat adapted itself to the very

different climatic conditions prevailing there and now spawns at any time from early winter to spring.

Dr. Paul R. Needham, of the United States Bureau of Fisheries, and Allan C. Taft, Division of Fish and Game, California, found that after some courtship activities the eggs are laid when the female drops back in the center of the nest in its deepest part. The male instantly moves into position parallel with the female, and eggs and milt are extruded at the same instant, the whole process requiring not much more than two seconds.

The eggs are covered in the same manner as those of the cutthroat trout, and after a few weeks the young emerge from the gravel. They stay in the stream for at least a year before going to sea.

The vitality of the artificially fertilized eggs has made it possible to ship them to great distances in a half-incubated condition, after which the hatching process can be completed by ordinary fish-hatchery methods. In this way fertilized eggs of the rainbow trout have been sent to the Atlantic coast, to Europe, and even to New Zealand in refrigerated packages with little loss.

The acclimatization of this fish in other parts of the United States and in foreign countries is one of the notable successes of modern fish culture. Taken to New Zealand in the late eighties, it soon became well established there, along with Pacific salmon.

With ever-increasing fishing, the continual restocking of trout streams has become more and more necessary and important but the supply of trout has not been materially increased even with the great efforts put forth by fish culturalists. Thus there arose the necessity for *stream and lake improvement*, which during the last few years has swept over this country like an uncontrolled forest fire. Stream improvement consists of improving the environment, increasing production of fish foods, and enlarging the spawning areas. This is accomplished by constructing obstructions or partial dams and current deflectors; by building covers or hiding places for trout; and by planting forests to stop dangerous erosion.

My experience in fishing for rainbows and steelheads in Glacier and Yellowstone National Parks indicates that a fly rod about nine feet long is best. The line must be heavy enough to carry the lure and leader to the distance desired in casting; and the flies most useful are Royal Coachman, Gray Hackle, Black Gnat, and one or two other designs on about a size-12 hook. Of course, a reel and other equipment are necessary, but the amateur trout angler can have great sport with a modestly priced outfit.

In the Skykomish River of Washington heavier rods are needed; for fishermen there have taken many 10- to 20-pound steelheads.



Painting by Hashem M. Al-Faraj

PRINCE OF SWIFT MOUNTAIN STREAMS, THE LEAPING RAINBOW TROUT IS A FAVORITE OF THE FLY FISHERMAN

Originating west of the Rocky Mountains and the Sierra Nevada, from Alaska to northern Mexico, the **Rainbow Trout** has been transplanted to the eastern United States and Canada, to Europe, and, with particular success, to New Zealand. When it goes to sea, this species is known as the **Steelhead Trout**. An important food fish that may attain a weight of 25 pounds, the steelhead variety reproduces in fresh water, but, unlike Pacific salmon, does not die after spawning. Both landlocked and sea-run variants take the fly readily and put up a sturdy and acrobatic battle.

Yellowstone, or Montana Black-spotted, Trout

(*Salmo lewisi*)

Usual Length, 12 Inches

The Yellowstone trout, only game fish in Yellowstone Lake, is closely related to the coastal cutthroat, but has fewer anterior and more caudal black spots. It is common in the mountain streams of much of British Columbia and the northern Rocky Mountain States.

In springtime these gorgeous trout take nearly any kind of bait. Yellowstone visitors with hook and line catch annually several thousand of an average weight of three-quarters of a pound. Sometimes it is possible to catch a trout in the cold water of Yellowstone Lake and, without moving a step, boil the fish in a hot spring on the shore.

In the Flathead River adjoining the west side of Glacier National Park, this black-spotted trout is caught by hundreds of visitors. Some hardy enthusiasts hike up to the headwaters of the tributary creeks or to mountain lakes where fishing cannot be excelled. There I have taken on a fly ten one-pound trout in a little more than 15 minutes. An 8- or 10-pound cutthroat is considered of record size.

The fish spawn in May or June in the smaller creeks to which the adults have migrated as soon as the ice is gone. In gravel riffles the females excavate saucer-shaped depressions, in which the eggs are laid.

The eggs hatch in from four to six weeks and the fry, or baby trout, soon begin to feed. The large adult trout usually move back into the lake soon after spawning, leaving their progeny to the care of Nature. Perhaps if they stayed with them in the streams they would begin to eat the little fellows they so carefully planted as eggs in the nests.

The chief fish hatchery in Yellowstone Park is operated at the north end of Yellowstone Lake, a short distance west of the Lake Lodge. This hatchery, operated by the U. S. Bureau of Fisheries, is supplied with cold running water.

In late April or early May, before the ice leaves the lake, the Bureau of Fisheries sends men to the hatchery to make repairs, get the boats used on the lake ready for service, and put everything in order for the hatching of the eggs of the black-spotted trout of Yellowstone Lake.

As soon as the ice leaves the lake, the trout begin their migration up the creek for spawning, and this continues until late in July. The fish hatchery attendants have egg-taking stations in Pelican, Clear, Columbine, Chipmunk and other creeks.

A short distance up the creek is built a weir directing the migrating fish into a trap. At-

tendants remove the fish from the trap into live boxes or pens where they are held until their ova and milt are ripe.

The ova are stripped from the females by gentle pressure on their abdomens, and allowed to flow into a pan. After the eggs of several female trout have been added to the pan, the milt from two or three males is directed into the pan and thoroughly mixed with the eggs; then water is added, and the mixture is thoroughly stirred. After a few minutes the eggs are washed and set aside undisturbed for an hour or so, then placed in a wooden keg for transportation to the hatchery.

Eggs thus prepared at several egg-taking stations located near the mouths of creeks are picked up by one of the Bureau of Fisheries motor boats on Yellowstone Lake and taken to the hatchery. Here they are placed in trays with a screen bottom submersed in running water, and left until hatching occurs, which normally takes about 4 to 6 weeks.

The Yellowstone Lake hatchery usually takes from 15 to 30 million of black-spotted trout eggs annually. Some of these are planted, as fry or just before hatching occurs, back into the streams tributary to Yellowstone Lake, or in other streams of the park. Many are shipped to other western national parks and forests to restock their depleted waters.

Three-spined Stickleback

(*Gasterosteus aculeatus*)

Usual Length, 3 Inches

The sticklebacks, family Gasterosteidae, of which there are several species in both salt and fresh waters, inhabit the Northern Hemisphere. The three-spined stickleback, found in Asia, Europe, and North America, is so named because of the sharp isolated spines on the back. Other sticklebacks have from five to twelve or more such spines.

Everywhere sticklebacks are known for their ability to build nests from available vegetation and debris, with front and back entrances leading to a tubular hallway. The male alone builds the small nest, or barrel-shaped house, out of "vegetable bricks" and cements them together with a sticky, thread-like secretion from his body. The nest is concealed in vegetation or in rock pools where there is a moderate flow of water.

The male continually goes in and out of his house, working the marine glue from his body over the inner sides, where it hardens. Upon completion of the nursery, he searches for a mate, and after elaborate courtship induces her into the nest, often by poking her with his snout or spines.

After eggs are deposited and fertilized in the nest, the male guards the entrances and charges furiously against all comers.



IN YELLOWSTONE PARK, A LOCAL WHOPPER MAY SNATCH YOUR LURE

In streams and lakes throughout the park and adjacent regions is found the **Yellowstone Trout**, one of the numerous species of cutthroat.



Paintings by Hashime Murayama

AN UNDERWATER ARCHITECT GUARDS HIS IGLOO-SHAPED NEST

Tiny male **Three-spined Stickleback** builds a house of bits of roots and stalks of water plants. Cementing is done with a sticky substance secreted by special glands. Several females lay their eggs within the nest, each deposit being fertilized in turn by the finny polygamist.



Photograph by H. Armstrong Roberts

EVEN IN REMOTE MOUNTAIN LAKELETS, ANGLERS PURSUE THE WARY TROUT

Because no boats are available, this party in Jasper Park, Alberta, has constructed a raft. Rainbow and Dolly Varden trout abound (Color Plates, pages 273 and 292). Most western trout rise readily to the fly, though bait is best for certain waters. Every year in Pacific and Rocky Mountain States millions of hatchery-raised game fish are distributed to the more heavily fished streams and lakes. Some of the more remote lakes are stocked by dropping parachute-equipped cans of baby trout from airplanes.



Photograph from Three Lions

ROPED FOR SAFETY, INDIANS LIFT SALMON FROM THE ROARING COLUMBIA

The wide-mouthed dipnet is repeatedly swept down with the current until an upward-bound salmon is caught. Then the net is hauled up hand-over-hand to the fisherman's stand, firmly moored to the rocks. A big, fighting salmon sometimes upsets a fisherman's balance and would tumble him into the rapids were he not protected by ropes attached to his belt. The man silhouetted against the sky has let down a ladder to one platform and is about to pull up a catch. Several fat salmon lie in the box at the right.



Painting by Hashime Murayama

WESTERNERS CAN TRUTHFULLY BOAST OF MINNOWS THREE FEET LONG

They have only to point to the toothless **Sacramento Pike** (upper three), of the Sacramento-San Joaquin River system of central California, and other similar species of squawfish inhabiting the Colorado and Columbia Rivers. All are voracious feeders, very destructive to other fish life. Also confined to rivers of the second largest state is the **Sacramento Sucker** (lower trio), a bottom feeder with a "vacuum cleaner" mouth that draws in small aquatic animals and algae.

The front and back entrances allow water to flow over the eggs, the current being aided by the movements of the fins of the guarding male. After the eggs hatch, he guards the tiny young for a time and keeps them in the nest or cradle until they swim so strongly that he cannot carry them in his mouth.

Sticklebacks are of no value as food for man, but in salt marshes, along shores of lakes, and in streams they keep down mosquitoes by eating the larvae. When other fish attempt to swallow sticklebacks, as they often do, the results are likely to be fatal for both predators and victims. The stickleback's pelvic fin spines lock into outthrust position and this causes him to lodge in the throat of his foe.

Sacramento Pike or Squawfish

(*Ptychocheilus grandis*)

Usual Length, 18 Inches

To the family of minnows and carps, the Cyprinidae of the fresh waters of Europe, Asia, North America, and Africa, belongs the Sacramento pike, alias the squawfish. It and its close relatives, *Ptychocheilus oregonensis*, from which it is barely distinguishable, are common in Pacific coastal streams from central California to British Columbia. In the springtime, about April, squawfish have been seen assembling in large numbers near the mouths of tributary streams. It is said that they spawn on gravel bottoms, but I have not seen any authentic account of their breeding habits.

The squawfishes are the largest minnows of North America; in the Colorado River they are said to reach a weight of 80 pounds. Frequently those taken in the Columbia River system are nearly three feet long and weigh from six to ten pounds.

They are voracious minnows with pikelike habits, the adults feeding mostly, if not exclusively, on other fish, including young trout and salmon. Like all other minnows or cyprinoids, they are without jawteeth, but they are quick enough to capture fish with their large mouths and to crush them far back in the throat by using their pharyngeal teeth.

Squawfish have a poor reputation among sportsmen. They are greedy for salmon eggs, worms, and insects, and will readily take artificial lures as well as frogs. The young make excellent bait for rainbow trout or bass.

The squawfishes may be recognized from other West Coast Cyprinids because their pointed and slightly hooked pharyngeal teeth occur in two rows; and their large mouth lacks the small fleshy barbel at the upper rear corner. The jaws are very long, the upper extending away back under the eye. There are about 10 rays in the dorsal fin and 8 in the anal. There are from 67 to 86 scales along the lateral line. *Ptychocheilus grandis* has from 36 to 41 scales on the upper edge of the back in front of the dorsal fin instead of the 46 to 56 which are present in *P. oregonensis*.

The food of the squawfish, because of its predatory habits, has received much attention by conservationists. Small ones, up to four inches in length feed almost entirely upon aquatic insects and small invertebrates. Squawfish 4½ inches in length and longer feed upon fish and occasionally upon insects. Now and then a squawfish 10 or 12 inches in length contains nothing but insects, but the squawfish that get two feet long are gourmands, feeding on such fishes as are convenient, including bullheads, *Cottus*; various Cyprinids; young silver salmon, and trout. In Cultus Lake, British Columbia, Dr. R. E. Foerster and W. E. Ricker report that the chief item of food was young sockeye salmon. So serious have been the depredations of squawfish on young sockeye salmon in Cultus Lake that the Province of British Columbia has carried on an extensive campaign to eradicate large numbers of them, and the result has been an increase in downstream migrating of red or sockeye salmon.

Sacramento Sucker

(*Catostomus occidentalis*)

Usual Length, 15 Inches

Several species of suckers, so called because of their peculiar mouths, occur in North America and Asia, but the Sacramento sucker and its close relative, the coarse-scaled Columbia River sucker, are confined to the coastal streams of western United States and British Columbia. By protruding their papillate lips, these fish feed on small organisms and plants growing on the rocks of stream bottoms.

Sacramento suckers may reach a length of nearly two feet, but average about 15 inches; the larger ones weigh several pounds. Because of their odd mouths and feeding habits, they are seldom taken on hook and line. They are not at all gamy and are of slight commercial value, except locally. Below dams along the Wenatchee River, Washington, Indians snag them with hooks attached to poles and salt or dry them for winter use.

The Sacramento sucker spawns in the early spring, migrating from lakes to the gravel beds of streams or from the big rivers to the smaller tributary streams. The males frequent the gravel riffles at these times, usually in greatest abundance at night. Apparently spawning occurs whenever a female is ready to deposit her eggs. At this time she ventures on the gravel riffle and is attended by one or more males, the eggs and milt being shed as the spawners, vibrating rapidly, swim a few feet upstream.

The pale-yellowish eggs are very sticky when first laid, attaching themselves firmly to the stones of the stream bottom. Hatching occurs in a week or so, and the almost invisible young make their way to the edge of the stream, where they live in the shallow, quiet water and in protected sloughs. Often young suckers occur in vast numbers along margins of lakes, or in pools left by a shifted stream.



Painting by Hashime Murayama

ARMORED WITH PLATES, SPINES, AND ROWS OF BONY BUCKLERS, THE MAMMOTH STURGEON PATROLS MURKY RIVER DEPTHS

In Pacific slope streams from central California to Alaska runs the **White Sturgeon**. Because of its scarcity, this species does not compete with the Russian form, eggs of which provide the finest caviar. The sturgeon is the largest fresh-water fish in North America. A record Columbia River specimen weighed 1,285 pounds and was 12½ feet long. Four long feelers hang in front of the suckerlike mouth. Besides small aquatic creatures, the sturgeon may swallow the eggs, deposited on the stream bottoms, of **Eulachon**, schooling in the background.

White Sturgeon*(Acipenser transmontanus)*

Usual Length, 10 Inches

The white, Columbia River, or Sacramento, sturgeon, found in both fresh and marine waters along the Pacific coast from Alaska to Monterey, California, is the largest fresh-water fish in North America. It belongs to a remarkable group of fishes, the sturgeon family, *Acipenseridae*.

Sturgeons occur throughout the Northern Hemisphere, in North America, Europe, and Asia. Certain species are confined to lakes and streams while others are anadromous like the shad, and Pacific salmons. There are two species in the Pacific coastal rivers, and about 5 other species east of the Continental Divide. In the Mississippi River is a close relative, the paddle-fish, *Polyodon spathula*.

All sturgeons are at once distinguishable by their five longitudinal rows of heavy bony scales or buckler plates, with spiny tips, along the side of the body. Between the plates, the skin is thick and rough. The mouth is located on the under side of the head, some distance behind the tip of the snout. On the under side of the snout in front of the mouth are four barbels, which are very sensitive and are used to locate food upon the bottom. In taking food, the mouth is protruded downward and the food sucked into it.

A specimen from the Fraser River, British Columbia, measured 10½ feet in length and weighed 1,015 pounds. Near Vancouver, Washington, in June, 1912, the largest on record was caught—a 12½-foot female weighing 1,285 pounds and containing 125 pounds of roe, which was made into caviar.

Now, however, the day of the big sturgeons is probably over in the Columbia River, and virtually all the caviar sold in this country is made from the reddish eggs of Pacific coast salmon. Modern power and irrigation dams may prohibit adult fish of this size from going upstream to deposit their eggs, or, if the journey is accomplished, the young may find it impossible to reach the sea by way of fish ladders built for salmon and trout migrants.

At present the total commercial catch of sturgeon for the Pacific coast of the United States is from 75,000 to 150,000 pounds annually. When the country was first settled, so many sturgeons were caught that they were hauled on shore and disposed of as a nuisance.

The white and green sturgeons are inoffensive so far as other fishes are concerned, except that occasionally they may take from their sand and gravel feeding grounds the eggs of the eulachon, *Thaleichthys pacificus*.

Sturgeons are bottom feeders, eating worms, insect larvae, small fishes, small clams, and aquatic plants. Spawning is said to occur in the spring in the lower courses of the rivers.

Eulachon or Candlefish*(Thaleichthys pacificus)*

Usual Length, 7 Inches

Similar to the salmon, the eulachon, a member of the smelt family, *Osmeridae*, migrates into fresh-water streams to deposit its eggs in the late winter or early spring. It is common from Bering Sea to the Klamath River in northern California.

The eulachon differs from all the other smelts on the Pacific coast in having the origin of the dorsal fin much behind the insertion of the pelvics. In all other smelts of this region the pelvics are inserted nearly under the origin of the dorsal fin.

Several other characteristics are useful in identifying this migratory species: There are weak canine teeth on the vomer, a bone in the front roof of the mouth. These, with the pointed teeth in the jaws, are often shed at the spawning season. There are about 17 to 22 gill rakers on the first gill arch; and the elongate anal fin has 17 to 22 fin rays.

The long-finned smelt, *Spirinchus dilatatus* has migratory habits similar to those of the candlefish. Into certain streams flowing down into Puget Sound this species migrates during November for breeding purposes, spawning in rather deep water, so that it is seldom caught.

I have caught in large plankton tow nets in Puget Sound at a depth of several fathoms the young of the eulachon and the long-finned smelt. At a length of about three inches these fish are nearly transparent, and appear to be feeding on tiny crustaceans.

Fish of this species, called locally Columbia River smelt, occur in February and in early March in the lower Columbia River system. Near the mouth of the Sandy River, Oregon, and in the Cowlitz River, near Kelso, Washington, large catches are made with dipnets, seines, rakes, all sorts of buckets, and even window screens and woven bed-springs as the fish congregate to spawn in the shallow water.

The eggs, of which each female bears about 20,000, hatch in 10 days to two weeks, but the larvae are seldom seen in fresh waters, nor is it known at just what size they migrate to sea. Occasionally young fish two inches long are captured in plankton nets at moderate depths in Puget Sound.

The flesh of these smelt is of a delicate flavor, and highly esteemed as food. Because of the oily nature of the eulachon the Indians formerly dried them and used them for candles; thus the name "candlefish." They burn readily, giving off much light, a little smoke, and an undesirable smell.

After going to sea, the eulachon feeds on oceanic plankton, small animals, and floating plants. The commercial catch of it makes up a fair portion of the three million pounds of true smelt taken along our Pacific coast.



Painting by Hashime Murayama

WEST OF THE ROCKY MOUNTAINS, THE PLUCKY BASS TRIBE HAS ONE LONE NATIVE REPRESENTATIVE

With artificial or live bait, Pacific coast anglers outwit the large and gamy **Sacramento Perch** which, like its eastern kin, is also a delicious pan fish. Long strings of her eggs, "glued" together by a gelatinous substance, are draped by the female over submerged roots and branches. The perch has been greatly reduced in numbers by the introduction to its Sacramento River range of carp and catfish that eat its spawn.

Sacramento Perch*(Archoplites interruptus)*

Usual Length, 10 Inches

The Sacramento perch is the only member of the sunfish and bass family, Centrarchidae, occurring endemically west of the Rocky Mountains. It is confined to the Sacramento-San Joaquin river basins.

Presumably this fish is a representative of the ancient fauna which extended across the North American Continent prior to the elevation of the Rockies. Fossil remains of this fauna are found in the Eocene Green River shales of Wyoming.

The California Fish and Game Commission has found that introduced carp and catfish have badly depleted the Sacramento perch by eating their spawn. Because the perch are not so pugnacious at spawning time as are their sunfish and bass relatives, the eggs and young are less protected.

Some effort has been made to propagate artificially the Sacramento perch, the Division of Fish and Game of California having hatched and raised this species at their Elk Grove Hatchery.

The perch do not build nests on the bottom in sand or gravel as do sunfish or bass, but spawn among submerged objects. The eggs, it is said, are held together by a gelatinous substance and laid in long strings, somewhat like those of the common yellow perch in the East. They are draped over submerged roots, old limbs of trees, and branches sunk in the water.

This species is said to reach a length of two feet, although the average size is from 8 to 12 inches. It takes the hook readily and ranks high as a game fish. Its food consists mostly of worms, insects, and small fishes.

Probably the new movement in this country called lake and stream improvement will greatly assist the Sacramento perch to regain some of its former abundance. The usual methods of improving lakes and streams are first, to study scientifically the factors necessary for the production of fishes, and then alter the detrimental factors so that the essential environmental requirements will be balanced and thus produce shelter, adequate food, suitable nesting or spawning areas, and in general a suitable habitat for the species that it is desired to encourage.

Usually the deficiencies in our lakes and streams have been brought about by the activities of man. In other cases there are natural deficiencies, inherent in the lakes and streams, which can be corrected, and thus productivity is increased.

Detrimental conditions brought about by man, directly or indirectly, may be summarized as deforestation, forest fires, overgrazing, straightening and deepening of streams, erosion, water pollution from mining and industrial

wastes, irrigation and irrigation ditches, dams in rivers in connection with power projects, and unwise recreational practices.

The methods used to improve lakes are as follows:

The water level of a lake that has an outlet, but fluctuates greatly, can be controlled by the proper dam, and thus the shoal areas, which normally produce most of the fish foods, will not be subject to drying conditions. The plants will grow better since the wave action along the shore will not continually erode a large area of the beach as the water level rises and lowers. The construction of jetties to prevent shore currents and cut down wave action helps. An additional aid is the planting around small lakes of trees which, when full grown, will serve as wind breaks.

When trees become very large, some can be felled along the shore of the lake. Their submerged branches will provide shelter for the fishes.

C. M. Tarzwell states that our principal factors in the food problems of lakes is fertility, vegetation, and forage fishes. Vegetation may be encouraged by installation of structures to reduce wave action and currents and thus to establish quiet areas suitable to the growth of aquatic plants. If plants are absent, these can be artificially planted.

Forage fish, so important in the diet of bass and large trout, can be increased by providing adequate shallows, plenty of cover, and suitable spawning conditions required by these species. Considerable study must be devoted to each species of forage fish so that it will be insured of adequate food at each stage and size in its life cycle.

In stream management are applicable many of the factors that apply to lakes, such as regulating the flow by building dams, preventing floods by reforestation, controlling overgrazing and forest fires, and reducing erosion. In the West, dams have been built across the outlets of headwater lakes so that the stream will have a continuous flow throughout the year.

A low temperature in trout streams can be maintained by planting trees and shrubs along their banks to give shade. These serve to check bank erosion too. It is well established that food organisms are very scarce on stream bottoms with shifting sand, for this erosion covers up the aquatic insects and kills them. Because bottoms composed of gravel and rubble are less subject to erosion, they usually produce an abundance of fish foods.

Sometimes the temperature of streams is too low to produce many food organisms because the rate of growth of such animals is faster in higher than lower temperatures. When small ponded areas and backwaters are established, and trees cut down to allow the sun to warm the water, a richer production of food occurs.



Painting by Hashime Murayama

SPRING DRAWS THE SALMON HORDES FROM OCEAN DEPTHS TO RIVER MOUTHS

Every year, in salt water along the shores of northeastern Asia, Alaska, western British Columbia, and the United States as far south as central California, millions of the splendid fish are captured in seines, in nets, and with hook and line. The commercial catch is second in volume and first in value to the fishermen (1937 figures). Two of the most valuable are the **Chinook** (upper pair), largest of Pacific salmons, averaging about 22 pounds, and the **Silver** (lower two).

Chinook, or King, Salmon*(Oncorhynchus tshawytscha)*

Usual Length, 36 Inches

Largest of the species of Pacific salmon in the genus *Oncorhynchus*, family Salmonidae, the chinook, or king, salmon occurs from northern Japan to Alaska and southward to Monterey Bay, California.

Its average size is about 22 pounds, though a record fish taken at Klawock, Alaska, weighed 101 pounds without the head. Usually the flesh is a deep salmon-red, but in some localities it is pinkish.

The chinook salmon usually migrates in the spring, April to June; and another run occurs in the autumn, August to November, the time of the migration depending on the river. In larger rivers, such as the Columbia, an additional migration takes place in summer, with stragglers going upstream most of the time.

These fish enter the smaller tributaries, where they seek gravel riffles on which to spawn. The average female produces from 3,000 to 11,000 eggs, which, buried in the gravel at the bottom of the nests, hatch in winter or spring.

The young remain in fresh-water streams for a year or two, feeding mostly on aquatic insects and worms, and when a few inches in length migrate to the sea. They usually return to spawn in their fourth or fifth year.

In the sea they feed voraciously on herring, anchovies, and other marine animals. They are caught in traps, purse seines, haul seines, and gill nets, and by trolling. The total commercial catch for this species along the coasts of the three Pacific Coast States averages some 33 million pounds annually, with a value of \$1,500,000 to \$2,500,000.

King salmon are caught on spoons, spinners, dead whole herring or sardines, and other small fishes fixed on large hooks attached to wire leaders with sinkers that will carry the lure to considerable depths as it is trolled behind a boat.

The depths and locations where salmon feed in the sea have not been definitely determined, but the fish have been captured 100 miles off shore and as deep as 540 feet.

One of the outstanding successes of fish culture has been the acclimatization of chinook salmon in different parts of the world. In 1872, the United States Commission of Fish and Fisheries established an egg-taking station (Baird Station, California) on a tributary of the Sacramento River for the collection of chinook salmon eggs. From the Baird Station salmon eggs were shipped to many remote lands, including South America, Australia, England, Continental Europe, Hawaii, New Zealand, and Tasmania.

Among those countries listed, Chile reports the presence of sea run salmon, and in New Zealand runs of chinook and sockeye salmon

are definitely established. The spawning migrations of these salmon have adjusted their runs to the change in seasons of the Southern Hemisphere.

Dr. F. A. Davidson and S. J. Hutchinson conclude that the failure of Pacific salmon to establish themselves in some places where they have been planted is the lack of one or more of the essential environmental factors found in their native range. Pacific salmon require for spawning clean gravel beds to hold and protect the eggs and plenty of cold running water for their incubation. Mud and sand bottoms and settling silt are always fatal to the eggs. Spawning always occurs in shallow areas.

Silver, or Coho, Salmon*(Oncorhynchus kisutch)*

Usual Length, 24 Inches

Along the coastal regions of the North Pacific, from Japan to Alaska and southward to Monterey Bay, the silver, or coho, salmon, average weight five to eight pounds, is taken commercially by trolling and in haul seines, purse seines, gill nets, and traps.

The flesh, which varies from pinkish to deep salmon red, is canned extensively. About 20 million pounds are taken annually in the United States, the value of the catch ranging from a half million to nearly a million dollars.

Large quantities of the fish caught are quick-frozen and glazed, then stored in modern refrigerator plants, where I have seen them piled up like cordwood. As the market will absorb them, they are shipped to the East. Some coho salmon is smoked, or kippered, making a delicious product. Eggs or roe of this species are used in making salmon caviar.

Although the silver salmon does not grow so large as the king salmon, it is a little more gamy when caught on hook and line, usually making several long, swift runs and two or more leaps from the water. The king salmon does most of its fighting under water.

The life history of the silver salmon is much like that of the other Pacific salmon. Spawning occurs in fresh-water streams in late summer and autumn, the time varying according to latitude from August to December. In Alaska the migrations occur in summer. After a year or two in fresh-water streams, the fingerlings, then from two to four inches in length, migrate to sea, where they remain from one to three years. They come back in their fourth or fifth year to spawn.

The ages of these salmon, as of the other species, can be read with fair accuracy from their scales. During the growth of the scale permanent concentric rings are laid down in the material of which it is formed. In seasons of rapid growth these rings are spaced farther apart, but in winter, when growth slows or stops, they are closer together and irregularly spaced. Thus each season leaves its record.



Painting by Hashime Murayama

TO REACH THE SHALLOW HEADWATERS, SALMON OFTEN MUST CLIMB CASCADES

Costly fishways preserve for them an all-water route to upper reaches of many dam-blocked rivers up which they go to reproduce and die. This **Red Salmon** differs from its kin, since it spawns in streams tributary to lakes. Soon after emerging from the eggs, the young move down to the lakes for a one-to-three-year stopover before going to sea. This species is much sought after because, when canned, its flesh is deep red and especially flavorful.

Red, or Sockeye, Salmon

(*Oncorhynchus nerka*)

Usual Length, 20 Inches

The red, or sockeye, salmon, family Salmonidae, also known as blueback salmon, is similar to the other Pacific salmon, occurring from northern Japan to Alaska and southward to San Francisco Bay, California. It averages about five pounds, with a maximum of twelve pounds at a length of about three feet.

It is taken commercially in purse seines, haul seines, traps, and other nets, but not by trolling, since it rarely strikes bait. The flesh is deep red and, when canned, is of excellent flavor. Annually in the United States from 7,000,000 to 25,000,000 pounds are taken, with a market value of \$500,000 to \$1,500,000.

At one time the greatest of all sockeye salmon streams was the Fraser River of British Columbia. The surface of the water would be literally paved with "the blue backed horde" when they came in from the sea to fight their way upriver to spawning grounds. The main part of the catch by Puget Sound fishermen was made as these fish were migrating to this magnificent salmon stream.

But in 1913 and 1914 heavy slides occurred while a railroad was being built, blocking the migration of the sockeye to their spawning grounds. Up to the present the sockeye have not regained their former abundance in this river, even though the obstructions to their migration have been removed.

To remedy the lack of rebuilding of the sockeye salmon stock in the Fraser River, the United States and Canada, on July 28, 1937, ratified a treaty for the study of this species.

Some of the red salmon are landlocked in lakes, never going to sea, although they could. These landlocked red salmon, or redfish, may be caught in Lake Washington, at Seattle, with hook and line during the spring and early summer before they put on their spawning dress of dark red to wine color. While in the lake they pass under the name of "silver trout" but by the time of the first autumn rain or even before, the "silver trout" find their way to the mouths of streams that flow into this lake.

In late August or early September, a few of the redfish, as they are now called, can be seen playing around on the gravelly riffles of the stream, but soon after the first big rain, which usually occurs in late September or early October, and which materially increases the stream flow, the redfish appear on these same riffles in greater numbers. During early November they are most abundant; then the numbers rapidly decrease, and by the last of December not a redfish remains where a few weeks before more than 125 fish could be counted in an area 20 by 40 feet.

I found that I could not see this large number unless I observed the greatest caution in

making my approach. Any sudden movement frightened the fish, and they would seek shelter in the deep holes above the riffle, seldom below, and hide for some time before venturing out. If I remained very still from five to 20 minutes, they would quickly swim back to their original position over the riffle, stay a moment, and leave for the deep hole again, soon to return.

After one or more such attempts, the redfish would remain on the riffle, oblivious of my presence. However, if I made any sudden movements, they darted away, and then I must wait for them to return and again become accustomed to my presence. Before long I would become so much a part of the environment to them that they would pursue their normal breeding activities.

While standing in water from three to 10 inches in depth near the upper end of a riffle, just where it begins to break over the stones, I observed redfish segregate themselves in pairs, and remain over certain small areas of the stream bed, sometimes in water so shallow that their backs were exposed. These pairs were male and female. The male was bright red in color, but the female was greenish red.

Soon I observed that the male was driving other fish away from the nest if they came too close. Now and then this defending male would catch his teeth in an invading male and both would struggle with might and main while drifting downstream before the defender's tooth grip would be shaken loose so that the fighters could separate.

Sometimes the intruder was not so easily driven away, and then the defending male would slowly swim toward him. When about a foot or so away from each other both fish would turn and swim parallel upstream, often for as great a distance as eight feet, before the invader either went away or made a dash for the nest. This escorting act might occur again until the invader either left the nest or took possession of it.

My attention was next attracted to the female, which was over the shallow saucer-like depression, about $1\frac{1}{2}$ by 2 feet, and two or three inches deep. Glancing around the stream near where I stood, I noticed about a dozen other such nests or redds and over each was a pair of redfish.

The female, I discovered after several hours of observation, was responsible for the excavation of the nest. She would turn over on her side and vigorously flex her body and tail four or five times against the bottom as this motion carried her a foot or more upstream. Her activity stirred up a cloud of sand and gravel which drifted downstream a few inches to a foot or more before it settled, the larger stones settling first so that just below the nest was a small mound. These nest-building acts I recorded as taking place as often as



Painting by Hashime Murayama

AFTER SPAWNING ON GRAVEL BEDS, ALL PACIFIC SALMON DIE

On riffles in clear, fresh water, the females scoop out shallow depressions and there deposit thousands of eggs. Simultaneously, the males shed their fertilizing milt over the spawn. Aided by the stream, the fish cover their nests with a layer of gravel. Smallest of our Pacific species, the **Pink Salmon** spawns in small streams not far above tidewater. From the lump on the back of the breeding males, the species is often called "humpback."

every three to five seconds. After a period of a couple of days the nests were completed, and the female was ready to deposit her precious eggs.

Sometimes between the intervals of nest building by the female, the male behaved peculiarly. As the female was over the center of the nest, I noticed that rather often the male approached her from behind and just touched his head or snout to her body in the region between the adipose fin and the pectorals. He would then move his body toward and against hers, and quiver vigorously for a second or two. This courtship act occurred about once a minute if the fish were undisturbed. Sometimes the male would swim back and forth above the female over the nest, or nudge her in the side with his snout.

Spawning occurs in the nest, the eggs and milt being shed at the same instant. After the eggs are laid, the female continues her digging operations a trifle above the nest, and the gravel and sand thus disturbed is carried by the current over the eggs so that they are buried under three or four inches of gravel. Hatching occurs in about two months.

The sockeye differs from other Pacific salmon, in that its eggs are usually laid in streams tributary to lakes. The young, after emerging, descend to a lake where they live from one to three years, or occasionally four years, before migrating to sea.

In the lake they feed upon plankton, mostly copepods and cladocerans, and do not grow fast unless there is an abundance of food. They migrate to sea at a size of from two to seven inches and continue to feed on the animal organisms making up the oceanic plankton. Usually they stay two or three years in the sea and return to spawn in fresh-water streams in their fourth to seventh year.

Pink, or Humpback, Salmon

(*Oncorhynchus gorbuscha*)

Usual Length, 18 Inches

Though pink, or humpback, salmon are found from northern Japan to Alaska and southward to central California, they are taken commercially in large quantities only from Puget Sound northward. Throughout their range they pass part of their life cycle in the sea and part in streams.

In southeastern Alaska these fish begin their migration from the sea in late June and continue until late September, but do not migrate far upstream to deposit their eggs. They usually spawn in the smaller streams not far above tidewater, or in the smaller tributaries near the mouths of the larger rivers.

Spawning does not begin in the streams until the middle of August, and the fry remain all winter, emerging from the gravel of their nest the next March or April, when they migrate directly to the sea at a length of about one

inch. They remain in the sea for a year and a half and return to spawn at two years of age. While at sea they grow to an average of three to eight pounds. An 11-pound pink salmon is considered record size. Thus the species is the smallest of the Pacific coast salmon.

It differs from the other species of salmon in having very small scales, even smaller than those found on the steelhead trout.

The name "humpback" is derived from the hump found on the back of the male while on its spawning grounds. A hooked snout, too, develops on the male as soon as it enters freshwater streams for spawning. The humpback is caused by the sudden formation of cartilaginous tissues between the back of the head and the beginning of the dorsal fin. The hooked snout results from rapid elongation of bones in its upper part.

For these and other salmon to be of commercial value they must be caught while on their way to the stream mouths before they enter fresh water. Their flesh loses its best flavor by the time the humpback and hooked snout have developed.

The gill net is one of the oldest and most popular forms of apparatus used in the salmon fisheries. Of the two kinds, drift and set, the first is used mostly in the estuaries of rivers and their channels. If the water is clear, these nets are used only at night but in silty or muddy waters they may be used night or day. Most gill nets are made of fine flax or linen twine but some use cotton twine.

Drift nets vary from 700 feet to 1800 feet in length and from 24 to 45 meshes in depth; a mesh is about 7 to 10 inches stretched or smaller depending on the species sought. These nets are hung in the ordinary manner, to a rope with cork floats to support the upper portion, and attached to a rope with lead sinkers, which keeps the net vertical in the water.

Set gill nets are made similar to the drift nets but vary in length from 60 to 600 feet with the same size mesh as the drift nets. Usually these nets are staked or anchored in quiet areas or in water with a moderate current.

On the Columbia River, haul seines play an important part in the fisheries. These nets vary in length from 600 to 2400 feet and are from 35 to 40 meshes deep at the ends, with as many as 140 meshes near the inner end of the wings. The middle of the net is composed of a long bag. The haul seines are worked on the numerous sand bars, such a noticeable feature in the tidal area of the Columbia River.

Only about 200,000 pounds of pink salmon were caught in the Pacific Coast States in 1934; nearly 300 million pounds were landed in Alaska that year.

The fish is taken commercially in purse seines, haul seines, and traps. Since it does not take the hook like the silver and chinook salmon, it is not considered a game fish.



Painting by Hashime Murayama

BABY SALMON GROW RAPIDLY AFTER RUNNING DOWN TO THE FOOD-FILLED SEA

Surviving smolts of all species migrate to salt water after spending from a few months to three years in the rivers or lakes. In contrast to the chinook and silver species, which provide excellent sport when hooked on a troll, the **Chum Salmon** is rarely taken by rod and line. Upon entering fresh water, the male salmon develops a hooked upper jaw.

Chum, or Dog, Salmon*(Oncorhynchus keta)*

Usual Length, 18 Inches

The chum, or dog, salmon occurs from northern Japan to Alaska and southward to the Sacramento River.

Like fry of the pink salmon, the young go down to the sea immediately after they emerge from their nests and remain there until maturity.

In their third to sixth year they return to the fresh-water streams of their birth to spawn, and after spawning they all die. This migration occurs in Alaska from June to November.

At spawning time they have attained a length of from two to three feet and a weight of from five to 12 pounds, never more than 16 pounds.

The careful observer has little difficulty in distinguishing the sexes of breeding salmon and trout, for the breeding male is usually more highly colored than his mate and his body is compressed (sides flattened), while that of the female is more rounded. Usually the snout is somewhat hooked or arched in the male; that of the female is normal.

Experienced fish culturists are able to tell the sex of spawning salmonids by feeling them with their hands, the males having on the underside of the abdomen two hard ridges.

The chum salmon builds nests on gravel riffle of streams and deposits its eggs in a manner similar to that of other species of salmon and trout. Eggs and milt are discharged at the same time, and Nature has so beautifully coordinated each step in the breeding activities that the eggs, or ova, are fertilized the instant they are shed.

If this action were less rapid, they would probably not be fertilized at all, for the current would carry the sperm downstream from the nest. The millions of spermatozoa making up the milt are inactive until they enter the water; then for about 45 seconds they swim about with great rapidity, but by the end of 1½ minutes all have become inactive and probably many have died.

The eggs, once they enter the water, change rapidly too. For about a minute after the eggs are in water, it is possible for nearly 100 per cent of them to be fertilized when active spermatozoa are present, but at the end of another four minutes in the water the shell of the egg has so changed that it is nearly impossible for a spermatozoan to enter.

All spermatozoa must enter the salmon egg through a single minute pore, the micropyle, in the egg membrane or outer shell of the egg; and after one spermatozoan has entered (it takes but a single spermatozoan to start development of the egg), it is impossible for another to do so. Should no sperm enter the egg within the first few minutes that the egg is in the water, the micropyle closes, and that egg

can never be fertilized because the process known as "water-hardening" has already begun.

"Water-hardening" is a physiological process by which water passes through the egg membrane (outer shell of the egg) into the space below it. This space between the yolk and the egg membrane is called the perivitelline space. The eggs of all salmon and trout swell up about one-third larger in size than when first laid, and the outer shell becomes so tightly stretched that the eggs are rigid and, when dropped, may bounce like rubber balls. The egg membrane is adhesive when first laid, but at the end of about three-quarters of an hour, after the completion of water-hardening, it is smooth and no longer sticky. This adhesive quality causes grains of sand to adhere to the eggs, and the added weight helps to keep them in the bottom of the nest until they are covered with gravel by the female.

Should any of the ova escape from the nest pit they probably would be swept by the currents downstream. Any eggs that escape the mouths of fish lurking in the vicinity ready to eat them, would never develop anyway, for eventually the current would carry them to the pools below, where they would settle to the bottom, gradually becoming covered with sediment that would cause them to be suffocated.

Other hazards await the eggs. Fungus often attacks them and may spread through the nest when the eggs are too crowded, but it can make little headway when they are well separated. Freshets often wash out the eggs of the salmon, and once they are removed from the nest they have little or no chance of survival. In certain areas the streams recede after the salmon have spawned, leaving the nests high and dry and thus causing the eggs to be killed. These, among other dangers, take their toll of the new crop of eggs and young fish planted so carefully by the mother salmon.

The chum salmon is not sought by sportsmen, since it does not take artificial lure or bait. The commercial catch is taken in traps, purse seines, and other nets.

The flesh is pale pink and, when canned, rather light yellowish. It is especially good for freezing, salting, and smoking, but is of an inferior quality when canned. In former years the chum salmon was not taken very extensively for commercial purposes, but in more recent times, for example in 1934, more than 73 million pounds were caught in Alaska and nearly 11 million in the States.

These salmon are generally caught in purse seines from Puget Sound to Alaska. Such nets are approximately 1200 feet long, and the wings are 120 feet deep and the bunt or center about 150 feet, all with 3¾-inch stretched mesh. The bottom or foot line is heavily leaded and to it are attached galvanized iron rings five inches in diameter through which



Painting by Hashime Murayama

STRANGE IS THE BOND BETWEEN A DICKENS HEROINE AND AN AMERICAN FISH

After the English novelist visited the United States, there was a craze for the pink-flowered calico supposed to resemble a pattern worn by the lively, brightly dressed character in *Barnaby Rudge*. Heir to her name is the red-spotted **Dolly Varden Trout**, common in Pacific coastal streams and lakes. In Alaska, Dolly Vardens are destroyed by the thousands every year because they feed largely on salmon eggs and fry; bounties are paid on their tails.

runs the 1½-inch hemp purse line. The upper edge of the seine is floated with corks attached to the head line.

Purse seine vessels with rounded sterns are best adapted for that type of fishing. The late Dean John N. Cobb, University of Washington School of Fisheries, stated that on an elevated section of the stern is set a movable platform on a pivot, at the after end of which is a long roller. The purse seine is stowed on this platform, the head rope with corks on one side and the foot line on the other, so that there will be no tangling when the seine is paid out. Mr. Cobb's account of the operation of the purse seine is very complete:

"When the lookout sights a school of fish the seiner is run down close to it and a rowboat launched. One man takes his place in this with the rope from one end of the seine and acts as a pivot, while the seiner circles around the school, the crew paying out the seine as she moves along. When it is all out, the vessel runs alongside the rowboat and takes aboard the other rope. This rope and the rope from the other end being attached to the power winch, the circle around the fish is rapidly narrowed, and the slack of the seine as it comes in is stowed back on the platform.

"Around the bottom of the seine and through the galvanized-iron rings about five inches in diameter runs the purse line. As this is hauled into the boat, the open space at the bottom is rapidly closed up just as a handbag would be through the drawing together of the pursing string at the top.

"During this operation the nonpower purse seiners have a man standing alongside the rail who throws a pole into the center in order to drive the fish away from the open section. He is so skillful in this work that almost invariably the pole comes back to his hand as the pressure of the waters forces it up again. When the bottom has been pursed up, the fisherman hauling by hand can move more leisurely, but with the power winches in use the hauling in of the net is a comparatively easy matter, and the pole thrower is dispensed with."

When all the fish are in the bunt, they are usually dipped out with dipnets and placed in the hold of the vessel.

Dolly Varden Trout

(*Salvelinus malma*)

Usual Length, 24 Inches

Like its nearest relative, the eastern brook trout, the Dolly Varden belongs to the charrs, family Salmonidae.

These two species differ from other trout (*Salmo*) in having light spots on a darker background instead of black spots on a lighter background. Also they have on the sides of the body a few scarlet spots, markings which are never present in rainbows, cutthroats, or

salmon. Dolly Vardens occur from northern Japan to Alaska and southward to northern California. Throughout this vast area they inhabit the coastal streams, often going to sea as "steelhead Dolly Vardens" and growing to large size. In most Alaskan streams they occur in schools. They are found as far up as the headwaters of the Flathead River in Glacier National Park, and I have also taken them in the headwaters of the Saskatchewan River.

The Dolly Varden trout differs from the eastern brook trout in several respects. The backs and upper sides are not mottled as in the brook trout but instead they are covered with light spots. Spots on the back are smaller and paler than the ones on the sides. In the brook trout the spots run together to give a mottled appearance. The dorsal and anal are spotted similarly to the body in both species. In general the Dolly Varden is more elongate and less robust than the brook trout. Both species have the red spots on the sides.

Unlike its close relative, the brook trout, the Dolly Varden is not one of the favorite game fishes of America. Although this species is not cultivated artificially and is the subject of continued fishing, yet it persists in most of the coastal streams and in Alaska occurs in great abundance.

The Dolly Varden trout is not a leaping fish like the rainbow trout or black bass when hooked, although it may rise from the water when striking the fly or other lure.

When in streams, this charr feeds largely on aquatic insects, such as mayfly nymphs, but in lakes the large ones live mostly on fish, such as whitefishes, suckers, and minnows.

Fish measuring two and a half feet and weighing from 8 to 10 pounds are common, and some reach a weight of 20 pounds or more. Voracious feeders, they strike almost anything that moves in the water, living mostly on small fish. Because they prey on young trout and salmon, they are out of favor with sportsmen.

They will take lures, such as artificial minnows and spinners, and will rise to a fly. The flesh, which is delicious when properly cooked, is often of a pale pink color similar to that of the Yellowstone blackspotted trout. Thus both of these species are known in some localities as "salmon trout."

The Dolly Varden trout is an autumn spawner. The adults pair off over gravel riffles and build saucer-shaped nests in which the eggs and milt are deposited at the same instant. These are then covered, and hatching occurs some weeks later.

After spawning, the large adults usually go back downstream to lakes or to deeper holes of larger streams and remain there most of the year. The young, found in the streams in summer, feed on aquatic insects, worms, copepods, and other small animal organisms.



Photograph by Eunice Thomas Miner

NATIVES SAIL THEIR BOATS TO GOOD CONCH GROUNDS

Headfirst over the side they plunge, sometimes swimming deep to search the bottom for the big, white shells. To remove a conch from its "house," natives knock a hole in the spire directly over the spot where the creature is attached. It can then be pulled out readily, if you know how!



Photograph by Sands

"KEEP HER STEADY WHILE I HOOK THAT SPONGE!"

Newly gathered sponges are of various shades from yellowish-gray to black. They must be thoroughly sun-dried and washed to remove the gelatinous substance surrounding the fibrous skeletal structure, and their odor during that period leaves much to be desired.

SEA CREATURES OF OUR ATLANTIC SHORES

BY ROY WALDO MINER

Curator of Marine Life, American Museum of Natural History

Paintings by Else Bostelmann

VOYAGING southward from New York toward tropic waters on a midwinter day, we gaze out over a leaden sea of dull-green color, lashed by the stiff, chilling wind. But the next morning we awaken to a balmy air and go on deck to behold the ocean miraculously changed to ultramarine blue, the dark, swelling waves crowned with snowy foam which churns up in the wake of the vessel in turquoise turmoil before reaching the surface.

Petrels follow the ship, skipping from wave to wave. Toward afternoon a school of porpoises glides in and out of the sea in never-ending chase, while flying fishes, glinting in blue and silver, dart anxiously from the water and sail long distances, flicking the wave crests with their tails to gain momentum.

We are in the Gulf Stream, that marvelous river in the ocean, which gives the North Atlantic its unique character and profoundly affects its temperature even as far as the North Sea, bestowing upon the British Isles and Scandinavia the inestimable boon of a chastened climate.

We can imagine the surprise of Ponce de Leon when, sailing along the coast of Florida in 1513, he found his ship borne irresistibly northward in its current. We acknowledge the service rendered to seamen by Benjamin Franklin, who advised vessels bound for England to take advantage of its northeastward course.

THE GULF STREAM'S MAGIC TOUCH

The Gulf Stream exerts an influence on the spread and distribution of the marine life of the Atlantic which cannot be overestimated.

The main current warms the whole North Atlantic, and spurs setting in toward the coast have a striking effect on the distribution of floating life off the Middle Atlantic States and southern New England. Here, however, the warm stream is separated from shore by colder waters forming what is known as the "Cold Wall." South of the Grand Banks of Newfoundland it meets the icy Labrador Current which flows down from the north, bringing a northern

fauna and making its influence felt along the shore, particularly north of Cape Cod.

The Gulf Stream, on the other hand, extends the range of many West Indian and other tropical species far to the northward during the summer, some of them being borne to the British Isles, so that the pelagic life of the mid-Atlantic is more tropical in character than that of the same latitude on the North American coast.

Let us sail out across the Gulf Stream in a southeasterly direction, keeping our eyes open for evidences of its floating life.

It is a calm day. Our seagoing launch glides over quiet waters, but the northeastward drift of the current is obvious.

Suddenly we see a graceful, translucent object, like an oddly elongated bladder, floating on the surface. It is brilliantly colored blue and crimson, the hues more intense at its tapering ends and shading into a play of delicate transparent tints along its sides.

LIVING FLEETS SAIL SUNNY WATERS

As we come nearer we see still others, and soon we realize that we are steering into the midst of a fleet of these fairy craft. Each one erects a crest resembling a succession of iridescent, foamlike bubbles along its summit, bordered with an edging of deep crimson.

These are the Portuguese man-of-war, an organism related to the hydroids and jellyfish, but consisting of a whole colony of connected individuals floating as a unit (Color Plate, page 310).

At first glance only one member of the colony is visible. But, as we look downward through the transparent water, we see masses of smaller tube-shaped projections depending from its lower side just beneath the surface. The majority are deep blue, while scattered here and there among them are clusters of salmon pink, and fingerlike protuberances of green. Fringelike strings edged with bluish beads float out from this mass, jerking spasmodically.

Looking deeper, we finally perceive, extending far into the depths, a whole series of cordlike filaments, spirally adorned with close-set beads similar to those on the

shorter strings, but larger. These slender cables are continually extending and contracting independently of each other, thickened knots passing each other up and down on neighboring strands like elevators.

A sudden breeze ruffles the water surface. The floats change shape, twisting in such a way as to "trim sail." The long, submerged cables, being attached to only one side of the bladder, act as a drag anchor, enabling the craft to head into the wind and thus counteract a too rapid leeway.

A MAN-OF-WAR'S POISON GUNS

On board the boat we have a tall glass jar. Reaching over the side, as the vessel drifts with the current, we pick up a fine example of *Physalia*, being careful to lift it by the float and thus avoid contact with any of the bead-adorned streamers. This caution is essential, for every bead is a battery of powerful sting cells loaded with minute barbed threads, thousands of which, at the slightest touch, will penetrate the skin and inject an irritating poison.

Once while wading near Ponce, on the south shore of Puerto Rico, I attempted to lift one of these creatures into a pail of water. The trade winds were blowing strongly, and, as the streamers came clear of the surface, the wind caught them and blew them around the bare arm with which I held the pail. Immediately a pain as of living fire shot through my flesh.

I quickly dropped the *Physalia* into the pail and began to unwind the clinging streamers with my free hand. When I had finished, each finger pained like an aching tooth. The arm was fiery red and swollen to the elbow, and my armpit ached where the poison had spread to the lymphatic glands.

I did not sleep that night, and the pain passed away slowly during the next day. Fortunately I was not seriously affected, but some people, more susceptible, have been known to collapse after being stung.

So we are extremely careful as we place our *Physalia* in our tall jar of sea water. The long streamers, which may extend as far as forty feet down into the sea, immediately contract to two or three feet when the bladder is brought out of the water. In the jar they lengthen to its bottom and begin their eternal contracting and extending.

The cluster of individuals immediately under the float is of several kinds, each

having a special function. The blue, tube-shaped members are feeding polyps, with mouth openings at their lower extremity. They do the feeding and digesting for the entire community. The green, tapering fingers are feelers and tasters, very sensitive. The finely divided pink clusters, reproductive in function, develop the sex cells. Male and female cells are found only in separate colonies.

The streamers, of course, are fighting polyps, the longer ones, as above stated, having a stabilizing function as well. Fishes or other organisms that chance to swim against the streamers are immediately stung to death and drawn up by the contracting filaments to come in contact with the mouths of the feeding polyps, which suck out the victims' body fluid, digest the food, and pass the excess on to the mouthless members of the colony.

A species of small fish, the Portuguese man-of-war fish (*Nomeus gronovii*), appears to be immune to the sting, and seeks among the tentacles shelter from its enemies. In return, it perhaps acts as a lure for larger fish preyed upon by its host, and doubtless joins in at the feast!

Butterfishes have a similar habit, associating with the red-rayed jellyfish (*Dactylometra quinquecirrha*). They take refuge beneath their "electrified" host's umbrella and even nibble at its tentacles.

Other floating colonies, related to the Portuguese man-of-war, are occasionally seen in the Gulf Stream. Among them are the *Porpita*, having a disklike float about the size of a silver quarter, bright blue in color, and the *Verella*, with a rectangular raft about two inches in length, colored blue, green, and pink, and with a curious elevated keel standing up cornerwise upon it.

PULSATING JELLYFISHES CARRIED TO NEW ENGLAND

Jellyfishes also are abundant in these warm waters (Color Plate, page 311). In fact, the *Dactylometra*, above mentioned, as well as the Portuguese man-of-war, are borne to the shores of New England by currents setting in from the Gulf Stream, and the former has become established there as a regular inhabitant.

Another beautiful creature comes to the surface close to our boat and we capture it with a hand net. In a glass jar it swims with the utmost grace, its purplish-brown



Photograph by Julius Kirschner

PHOEBUS, GOD OF THE SUN, DRIVES HIS CHARIOT ACROSS A HELMET SHELL

This exquisite carving is from the original Guido Reni painting "Aurora" exhibited in Rome. Before the chariot the Goddess of the Dawn sprinkles flowers over the clouds. Cupid, bearing a flaming torch, represents the morning star. For this work, the artist chose the shell of a helmet conch instead of a queen conch (Color Plate, page 312), because the white exterior and brownish lining give more contrast than the white and rose of the queen conch (page 306). Mr. J. P. Morgan presented the shell, cut in Italy, to the American Museum of Natural History in New York City.

umbrella pulsating rhythmically as it propels the creature through the water.

This is the purple oceanic jellyfish (*Pelagia cyanella*). It possesses the four long, ruffled mouth lobes familiar in *Dactylometra*, and eight slender tentacles margin the umbrella, which is further ornamented with numerous small wartlike knobs.

The mushroom jellyfish (*Stomolophus meleagris*) is smaller. Its almost globu-

lar, brown to cream-colored umbrella, unadorned with tentacles, gives it nearly the appearance of a swimming mushroom, an impression emphasized by the stemlike cluster of folded and scalloped mouth lobes furnished with numerous suckers which function instead of a mouth (Color Plate, page 311).

As we look down through the water, we see, contracting and pulsating everywhere,



Photograph by Roy Waldo Miner

CRAYFISH "PLAYING POSSUM," BUT STILL FULL OF PEP

Unless handled skilfully, the lobsters, armored with sharp spines, can lacerate the hands, for the creatures struggle vigorously. These were captured in traps, but native market fishermen also find them by using the water glass and capture them with long-handled tines. Crayfish are found lurking in rock crevices at low tide throughout Florida and Bahama waters (page 306 and Color Plate, page 313).

the bubblelike globes of smaller medusae, so transparent that they are only momentarily visible as the light glints across their delicately tinted umbrellas and faintly outlined radial canals. Most of them are hemispherical, but here and there are cuboid forms (*Tamoia haplonema*), angular in outline, with two or four tentacles at the corners.

Among these lovely phantom creatures are certain species with iridescent flashes of brilliant prismatic colors playing in narrow lines over their otherwise nearly invisible

surfaces. They are the ctenophores, or comb jellies, which form a group distantly related to the true jellyfishes (Color Plate, page 311).

The flashes of colored light are caused by tiny propelling appendages shaped like infinitesimal combs, arranged in eight radial rows over the surface of the body. They move rapidly back and forth in ordered succession, the rays of light being diffracted into countless tiny rainbows by the unbelievably fine teeth with which each comb is equipped.

Most ctenophores have a pair of long, branched tentacles armed with sting cells. These appendages act as snares for small food creatures and may be retracted into transparent, pitlike sheaths.

A common species (*Pleurobrachia pileus*)

has an oval body like a transparent plum. It is extremely widespread in the Atlantic, occurring from the Arctic to the Antarctic, and from Europe to America. It swarms abundantly in the Gulf Stream, as well as in the waters which lie close to the New Jersey coast, the Virginia Capes, and Cape Hatteras.

The powerful stinging tentacles are very destructive to small crustaceans such as copepods and shrimp, which are important factors in the food supply of many of our fishes (some of which, in turn, feed upon the

ctenophores). The creature is therefore of considerable significance in the balance of life.

The Venus's-girdle (*Cestus veneris*) is one of the most striking of the ctenophore group. Its filmy body, bandlike in shape, resembles a transparent ribbon and is often three feet long (Color Plate, page 311).

CAPE COD ACTS AS BARRIER

As it swims, undulating through the water, its ends keep rolling and unrolling in scroll-like fashion, while the rows of comb plates along the margin shimmer with iridescent colors, especially green, blue, and violet. This beautiful creature is more common in the Tropics, but the Gulf Stream occasionally brings it northward as far as the southern New England Coast.

Cape Cod and the Labrador Current together form an efficient barrier which prevents the more southern species, such as these, from reaching the northern New England region, though some may be carried far north of this latitude toward Europe.

On the other hand, Cape Cod, because of its barren, sandy character, also acts as a barrier to the northern shore fauna, keeping it confined to the Gulf of Maine, Nova Scotia, and Labrador.

Nevertheless, in recent years, such species of mollusks as the indefatigable periwinkle, dog whelk, and "buckie" have



From a painting by Albert Operti

AN ARTIST'S CONCEPTION OF SEA LIFE IN A MANGROVE SWAMP

Clinging to the mangrove roots are coon oysters (just above water surface) and spotted cowries (lower left and left center). Beneath them rests a starfish. Three tube sponges rise from a root, and near by crouches a slender-legged spider crab. Beyond are living cup corals and sea fans. Careful scrutiny reveals many tiny brittle stars that lie flat on the bottom, arms radiating in every direction.

slowly surmounted this obstacle and are now found on the coast of southern New England and Long Island Sound.

Warm and cold currents determine the spread of floating sea life, while barren stretches of shifting sand are difficult for many of the creeping animals of shallow waters, and only those survive that are particularly adapted to such conditions.

The inlets and sheltered waters of Long Island, with their bottoms of mixed mud and sand, harbor an abundant fauna of their own, but south of New York the long barren stretch of the New Jersey sand



Photograph by H. S. Jennings

WOE BETIDE THIS "POOR FISH," CAUGHT IN THE MAW OF A SEA STAR

Struggle though the butterfish may, it cannot dislodge the hundreds of tiny feet equipped with suckers. The starfish will gradually digest its living meal, tail first. Butterfishes sometimes hide beneath jellyfish "umbrellas" to escape their enemies.

beaches interposes another barrier. These are so predominantly siliceous that they support few species of shallow-water marine animals and effectively prevent the spread of others in both directions.

Hence, we enter another zone of distribution as we trend southward toward Cape Hatteras. The coast is once more characterized by sunken valleys like that of the Gulf of Maine, but not so extensive. Delaware and Chesapeake Bays, Albemarle and Pamlico Sounds shelter numerous coastal species, but the range of shallow-water life offshore is limited by the rapidly narrowing continental shelf, as compared with the wide banks northeast of New York opposite the Gulf of Maine.

Off Cape Hatteras the open-water fauna is abundant near the shore. Here the Gulf Stream, with its masses of floating plankton, is close to the edge of the narrow oceanic shelf, while its tropical influence gives a southern tinge to the shore fauna. South of Cape Hatteras barren conditions

once more prevail, and shore species are comparatively sparse, while the sea bottom is scoured of its deeper life by the swift current of the Gulf Stream.

But southern Florida presents a striking contrast, with its tropical climate and extensive continental shelf. This submarine platform, though cut by the Gulf Stream in the Straits of Florida, nevertheless reaches far eastward to include the Bahama Islands. Here we pass into the West Indian world, with its hosts of tropical marine species.

To emphasize the contrast between the barren shore just south of New York and the teeming life of the tropical Florida shallows, let us visit a part of the southern New Jersey coast toward dusk.

GHOST CRABS ARE FLEETING

A sandy beach extends into the distance until its continuation is hidden by the curve of the shore. It is bounded inland by the sand dunes, their snowy sides diversified by



A TRUNKFISH BLOWS SAND AWAY FROM ITS FOOD

Six small slippery dicks hover about to snap up stray tidbits. A yellow tail is turning away (right). Such attendants often follow the actively feeding trunkfish.



Photographs by W. H. Longley

YELLOW GOATFISHES SLIP THROUGH GAPS IN THE CORALS

Two of them (right- and left center) distinctly show the pair of barbels beneath the chin to which they owe their name. The two striped fish are yellow grunts.



A PAIR OF PLATTER-SHAPED BLACK ANGELFISH SWIM ALONG THE OPEN REEF



Photographs by W. H. Longley

TUFTED HEADS OF SEA WORMS PROTRUDE FROM A SMALL CORAL

The worms are variegated, the coral often brilliant yellow, and the shallow sea where this kind of life is found is gay with light and color. Long-spined sea urchins abound in crevices of the reef rock as well as in the open. Hazy in the background are long, dark "arms" of gorgonians.

beach grass and stunted vegetation. Long lines of beach wrack brought in by the tides parallel the water's edge. The sands seem empty of life and movement except for the wash of the sea.

But not quite!

There is a shadowy stir by the dead seaweeds—and another like a fleeting wraith farther up the sands. We blink our eyes, for it has vanished. Now there is a start directly in front of us and a ghostlike creature materializes before our very eyes, only to disappear apparently into thin air. We focus our gaze more carefully, and, at the next sign of movement, follow it eagerly.

WRAITHS ON THE BARREN SANDS

Now, at last, we identify a swift, silently moving form, a set of scampering legs, and a pair of shining black eyes erected on upright stalks. We have stumbled on a community of ghost crabs (*Ocypode albicans*), and well do they deserve their name (Color Plate, page 309).

Their pale, yellowish-gray carapaces match the beach so exactly that when they are stationary it is almost impossible to see them. They are betrayed only by their swift movements as they glide over to the beach wrack to snatch a sand hopper or two, and quickly dart back to their homes when alarmed.

Their abodes are burrows dug deep into the sand above the high-tide line. The entrance is a round hole flanked by a sand heap, where they stand guard or retreat until only partly visible in their doorways.

If we approach, they vanish inside in a twinkling. It is almost impossible to catch them, so fleet are their movements. We secure a few specimens only by flinging a hand net over them from a distance as they dart across the beach.

If cut off from their homes, they will take refuge in the sea, but it is apparent that they do not enjoy a watery environment, for at the first opportunity they dart out and make for their burrows.

They seem veritable creatures of the sand, being adapted to it by their concealing coloration, burrowing habits, agility, and speed, as well as by their custom of feeding upon the small crustaceans living in the jetsam of the sea.

But even these dwellers on the barren beach are invaders from the south, for this is the northern limit of their range. There are a few doubtful records of their hav-

ing reached Long Island, and their free-swimming larvae often have been found as far east as Block Island and Martha's Vineyard.

Apparently the cold winters prevent the adults from becoming established north of New Jersey. To the south they range with increasing abundance to Florida and the West Indies, while on our New Jersey beach they have merely established their venture-some outposts.

Contrast this bleak barrenness with the balmy and prolific region from which they have migrated in the south. It is, of course, a sea abounding in coral reefs, with an amazing undersea life. But we shall speak of the interesting creatures of the quiet lagoons enclosed between the reefs and the shore, as well as of those that have invaded the low-lying beaches and the extensive shallow mangrove swamps that abound here.

The corallagoon is the area of quiet water protected from the open sea by coral barriers and lying between them and some near-by coast. The lagoon floor consists of coarse, white calcareous sand derived from materials washed in through the reefs by the tides and currents. Isolated clumps and shoals of living corals rise here and there toward the surface and small islands or "cays" of eroded aeolian limestone diversify the prospect.

WATER ALMOST AS CLEAR AS AIR

The sea is very transparent, and on quiet days the boat seems to be floating in air, while the sandy bottom with its denizens shows with the utmost clearness.

Huge sea stars (*Oreaster reticulatus*) slowly crawl about looking for mollusks (Color Plate, page 312). They vary in color from red to blue or purple and are marked with an intricate network of raised ridges forming a pattern of triangles decorated with small knobs. They are the largest of the West Indian sea stars.

Conchs of two species are especially abundant. One, the queen conch (*Strombus gigas*), is the largest sea snail found in American waters, some specimens growing to a foot or more in length (Color Plate, page 312).

The thick shell has a coiled spire nearly obscured by the flange of the broadly flaring lip, its lining a brilliant rosy pink.

When the creature is alive, the narrow foot of the thick-skinned, muscular body



Photograph by Roy Waldo Miner

A SCIENTIST EXPLORES A MANGROVE SWAMP IN SOUTH BIGHT, ANDROS ISLAND

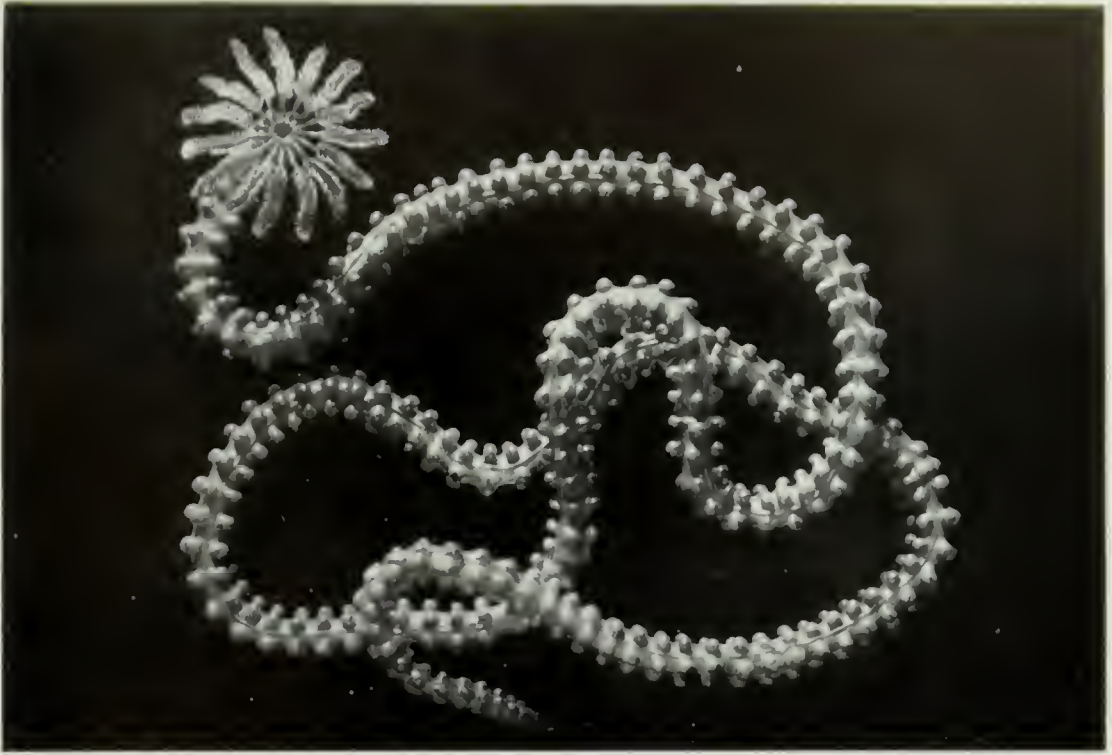
With an outboard motor, he works in and out of the coves to rake from the muddy ooze shells, worms, and other forms of burrowing life. Lime impregnates the water on the west side of this Bahama island, forming the hard crust visible on the mangrove roots beyond the boat.



Photograph by Sands

NIMBLE FINGERS QUICKLY TRIM THIS ODORIFEROUS MOUNTAIN OF SPONGES

After a boat docks at Nassau in the Bahamas, its cargo is spread under a shed along the water front, and dealers purchase the sponges at auction by the "lot" or boatload. Buyers cart them to huge yards, where they are trimmed and sorted by women. Odds and ends become fertilizer or packing material, and finished sponges are shipped out in large bales (page 325).



Photograph by R. E. Dahlgren

LIKE A PEARLY NECKLACE SEEMS THIS MODEL OF A THREE-FOOT DENIZEN
OF ANDROS ISLAND

Knobs on the body of the giant *Synapta*, a genus of holothurians, or sea cucumbers, are soft and pliable, and aid the animal in creeping. Highly sensitive petal-like tentacles or feelers on the head locate and entangle food particles. The creature is related to the sea stars and sea urchins, but not to the eel.

projects from the aperture, armed with a horny, hooklike spine. By means of this, the conch pulls itself actively about on the sea floor, digging the hook into the sand and moving in irregular hops and jumps. It causes the heavy shell to rock wildly from side to side in its haste to escape pursuers. This interesting creature is a scavenger, its food consisting of dead and decaying animal life.

One of the occupations of the Bahaman negroes is "diving conchs." As our launch lies anchored in a lagoon at Andros Island, we see the homemade sailboats of the natives drifting about slowly, while the occupants scan the bottom through a water glass.

Suddenly there is a splash as a negro dives overboard. Soon reappearing, his dripping body gleaming like polished mahogany, he hands up a conch over the gunwale, then drops back to get another (page 294).

Sometimes conchs are baited with meat, the odor of which attracts them in large numbers, and thus more may be caught in a short time by diving.

Conchs form an important article of food for the native islanders. In fact, the divers themselves are often termed "conchs" to distinguish them from persons not born in the islands.

Conch shells are sold for ornamental purposes and are familiar everywhere, especially in country districts in the United States, as parlor ornaments, doorstops, and borders for garden walks. They often secrete "conch pearls" of a beautiful rose color, which are mounted as jewelry and have a moderate value. The shells, with the tips of their spires sawed off, are sometimes used as dinner horns by natives.

The helmet shell (*Cassis madagascariensis*) is another conch common in the West Indies and often associated with the queen conch on sandy lagoon bottoms. It almost equals the latter in size (Color Plate, page 312).

This huge snail creeps about on a flat foot, searching for the bivalve mollusks on which it feeds.

The shell is indeed shaped like a white helmet, with a broad, flat, cream-colored

lip, blotched and striped with a deep chocolate brown. It is quite thick and of fine texture, composed of layers of white shell over the deep brown.

Since about 1820 it has been exported to Italy and France for making cameos, and has practically superseded the more expensive semiprecious stones formerly used for that purpose. Beautifully delicate carvings are made, standing out in white bas-relief against the brown background. Rome, Genoa, and Paris are the most noted centers for cameo cutting.

The queen conch is also used for this purpose, but not so extensively. Cameos made from it show a rose-colored carving against a white background, but because the rose tint tends to fade upon too great exposure to light, eventually these cameos lose much of their contrast, and those made from the helmet shell are more highly favored (page 297).

SPINY LOBSTERS LURK IN CREVICES

Here and there rocky shoals and coral clumps rise from the sandy floor of the lagoon. The crevices and holes with which they abound are the haunts of the spiny lobsters (*Panulirus argus*).

These weird creatures are about the size of the northern lobster, but lack the large pincer claws. However, they are so completely equipped with hooklike spines that it is difficult for anyone to handle a living animal without suffering injuries (Color Plate, page 313).

Brightly banded, striped, and spotted with brown, black, green, and cream color, they are conspicuous objects when caught in the hand net. Habitually, however, they avoid the light and hide in their dens during the day. Toward evening they come out, and then it is possible to capture them more readily than at any other time (page 298).

Like the northern lobster, they move about the sea bottom on the tips of their claws, or swim rapidly with oarlike motions of the swimmerets beneath the abdomen. They attain their greatest speed in retreating from enemies by vigorous flexion of the terminal joints of the abdomen. This peculiar activity furnishes the power to drive them swiftly backward after the manner of the common lobster.

Their armored bodies are covered with hairs sensitive to the slightest touch, and they have a keen sense of smell by which

they can readily detect the presence of food animals even at a considerable distance. They feed upon small bottom creatures such as shrimp, mollusks, and worms.

Many enemies attack them, and they especially fall prey to the larger reef fishes, such as the grouper and jewfish. One authority states that sixteen large lobsters were found in the stomach of a 350-pound jewfish.

Spiny lobsters are very important in the seafood markets of Florida and the West Indies, the tail furnishing a meat of delicious flavor.

MANGROVE SWAMPS RICH IN LIFE

The low-lying keys and reefs off the Florida coast, as well as the numerous inlets connected with the open sea, are bordered with areas of shallow water, where, in sheltered places, extensive mangrove swamps occur. These remarkable plants grow here with great luxuriance, their branches covered with thick, glossy leaves interlacing to form continuous thickets. Their slender trunks are braced by buttresslike aerial roots, which are spread out on all sides and are firmly embedded in the calcareous mud (page 299).

The warm, shallow waters are rich with life of all sorts.

Extensive beds of coon oysters (*Ostrea frons*) project from the white mud at low water, and even grow up on the aerial roots of the mangroves, hanging in bunches like a strange sort of fruit, so that they are often spoken of as the "oysters that grow on trees" (Color Plate, page 314).

The crown melongena (*Melongena corona*), a handsome whelk about the size of a pear, preys upon them avidly. They are very sweet and, though the meat is smaller than that of the Virginia oyster, it is nevertheless well worth the trouble of extracting for food.

These oysters are abundant from Florida and the West Indies to North Carolina, and throughout the coast of the Southern States are much sought after by raccoons; hence their popular name.

The spotted cowry (*Cypraea exanthema*) is very abundant here. Its polished chestnut and bluish-white shells decorated with round white spots cling to the stems of the mangroves. When submerged, the voluminous and conspicuously colored folds of its mantle emerge from the shell opening on both sides and slide up symmetrically,



Photograph by Roy Waldo Miner

"A SHILLING APIECE FOR YOUR HELMET SHELLS!"

The cost of a good one is a matter of bargaining, and of the native's whim. A shilling is a good price, though a sixpence (about 12 cents) may sometimes be accepted if the seller has a large number to market. The colored natives of the Bahama Islands are locally called "conchs."

nearly covering its smooth surface to the middle line and laying down a thin, glossy layer of porcelain as they do so.

Brightly colored mangrove crabs (*Goniopsis cruentata*), their square carapaces aglow with scarlet marked with brilliant yellow and blue, scamper over the oyster beds. Here and there in the shallow pools are seen the more soberly attired mud crabs (*Panopeus herbstii*), recognizable by the black fingers of their claws and the arched, saw-toothed margin of the carapace.

Leaving the swamp, we round a rocky point where, among the cavities and pinacles of the "honeycomb" limestone rock, hundreds of small snails cling to the rough stone, awash or between the tidemarks.

Three species having strongly arched shells are abundant, belonging to the genus *Nerita*. The smallest, about one-half inch

in diameter, is finely marked with a black-and-white checkerboard pattern (*Nerita tessellata*); another, somewhat larger (*Nerita versicolor*), is distinguished by close-set rounded ridges gaily decorated with red, black, and white squares and blotches; the third (*Nerita peleronta*) is the well-known "bleeding tooth." Turning it over, we find that the mouth opening bears two flat teeth on its white inner margin, one or both of which are blotched with yellowish red resembling a bloody stain.

The zigzag periwinkle (*Littorina ziczac*) is also here, its cone-shaped spire marked by fine zigzag lines of brownish yellow. Like the bleeding tooth its shell is popular with youngsters who gather souvenirs along the beach.

Large chitons cling tightly in the hollows near the water line, their oval bodies pro-

tected by an armor of jointed plates bordered with a zone of feltlike spines.

Tropical rock crabs, the "Sally Light-foot" (*Grapsus grapsus*), swiftly scamper over the rocks in all directions, especially where they are drenched by salt spray. These creatures are found everywhere in the Tropics in similar situations. Their thin, squarish carapaces are brightly marked by yellow and red lines, and long, flat, jointed legs bear them agilely over the rocks with such speed that it is very difficult to capture them.

LAND CRABS SCUTTLE ABOUT AT DUSK

We step off the outcropping of rock onto a white beach of calcareous sand. Thickets of sea grape grow along its upper margin under the coconut palms, diversified with low, flat clumps of beach lavender, the pale-green leaf clusters of which are covered with a whitish bloom, like dusty miller.

Even here animal life is abundant. Large land crabs of two species—the red mountain crab (*Gecarcinus ruricola*), purplish red with pale-yellow markings, and the great white land crab (*Cardisoma guanhumi*), with shell of bluish gray to yellowish white—dig extensive burrows in the sand with their powerful claws (Color Plate, page 315).

These huge crabs scuttle about awkwardly, but with considerable speed. They come out in large numbers at dusk, and if we are walking along the beach in the darkness, they are likely to come bumping against our legs. Both species dig their homes not only near the shore, but also on the low, wooded hills.

Each year they migrate to the sea in immense armies. There the females enter the surf to wash off the eggs clinging to the underside of their abdomens, and thus allow them to hatch. Then the adults return to their abodes in the hills, to be followed about two weeks later by the migration of their newly hatched young.

Red mountain crabs have a delicious flavor when boiled, stewed, or baked in the shell.

The land hermit crabs (*Cocnobita diogenes*) run along the beach, foraging among the dead leaves and the decaying trunks of fallen coconut palms. Their spiny pincer claws are brightly colored red and blue, and, like our northern hermits, when disturbed they quickly withdraw into their shells, blocking the entrance with expanded pincers.

They utilize empty mollusk shells for homes, and, when they outgrow them, promptly investigate all new possibilities, alternately trying various shells and popping back into the old one for comparison. Finally they select the most comfortable abode, though they may walk off with the original shell, after all.

Apparently they are willing to try anything that at all resembles a shell, for one of our expeditions from the American Museum discovered a hermit crab on a Bahaman beach that had adopted the bowl of an old clay pipe for its abode! This specimen, pipe and all, is now on exhibition in the Museum (Color Plate, page 315).

Coral reefs and sand bars are typical of the eastern or windward side of the Florida coast and the Bahama Islands. On the westward, or sheltered, side of the larger bodies of land, coral reefs are practically nonexistent, and the sea is floored with a very soft calcareous mud.

This is true especially of the Great Bahama Bank between the Straits of Florida and Andros Island. A curious spreading seaweed known as "old man's beard" grows over the muddy bottom, and here and there are outcrops and ledges of old limestone rock. These are the great sponge banks. Here and on the Gulf coast of Florida most of the commercial sponges of American waters are harvested for the market.

"NEEDLES" IN SOME SPONGES

Many species of sponges cannot be used commercially because of the glassy spicules or needles embedded in their tissues. This is generally true of the northern sponges, and there are many species in the Tropics as well that belong to this category.

Several of the latter are shown in the Color Plate on page 316. The spiny tube sponge (*Spinosella sororia*) grows in clusters of trumpet-shaped chimneys of papery texture, too hard and resistant for commercial use, even were it not for the spicules. The shorter yellow siphons of the tuba sponge (*Tuba bullata*), though of much finer and more delicate mesh, are also unsuited for this purpose.

Some sponges, like the red branched sponge (*Pachychalina rubens*), grow in colonies made up of long, branching fingers, with conspicuous oval oscula scattered at intervals over the sides. Brilliant encrusting sponges, like the scarlet fire sponge (*Tedania ignis*) and the colorful, soft,



GHOST CRABS SCUTTLE ACROSS THE BEACH TO SNATCH A MEAL OF SAND HOPPERS

When motionless, these yellowish wraiths, with black, glistening eyes mounted on stalks, blend with the sand. In the faint light of dusk, the yellow carapaces seem of lighter color when viewed from a distance. A seemingly pale **Ghost Crab** (upper right) rests beside a burrow, its refuge in times of danger. These creatures are very active and hard to catch. New Jersey marks their northern limit, and they become increasingly abundant southward along the Atlantic coast. The empty shells of the **Sand Collar Snail** (lower left) and the large **Channeled Whelk** (left center) were cast up by waves. Edges of dead scallop shells protrude from the sand in the lower right corner.



A FAIRY FRIGATE DRIFTS NORTHWARD ON THE GULF STREAM

Dealing death to tiny tropic dwellers, the **Portuguese Mau-of-war** seems an iridescent, bubblelike craft. Actually, it is a colony of cooperative polyps, each with a special function. The "sail" or crested bladder of the mother unit, contains gas that keeps the craft afloat. Green polyps feel and taste, blue ones absorb food, and the pink are reproductive organs. The long streamers bear batteries of nettle cells so powerful that shipwrecked sailors stung by them have been known to die. The tentacles paralyze fish and convey them to the "mouths." Curiously, the **Portuguese Mau-of-war Fish** (lower) lives unharmed among the streamers, probably acting as a lure and sharing the prey.



SEA NETTLES AND SOME COUSINS THAT LURK IN DEEP BLUE WATERS

Graceful and rose-flecked, the **Pelagia** (upper right) propels itself by expanding and contracting the umbrella. Slender tentacles, armed with sting cells, hang from the border to entangle the prey. Vast swarms of the **Mushroom Jellyfish** (lower left) sometimes carpet the ocean in patches 100 miles long. The animal has no mouth, and uses instead curious mouth lobes equipped with suckers. The **Cuboid Medusa** (upper left) swims in the open sea. Two species of comb jellies are shown: the ribbonlike **Venus's-Girdle** (lower right), which rolls and unrolls as it swims, and the delicate **Rosebud** (left center).



QUEEN CONCH, LARGEST OF AMERICAN SHELLS, MAY END UP AS A DINNER HORN

These giant sea snails, one resting on its side above, attain a length of a foot or more. The meat makes fine chowder, but fishermen cut it up for bait. If alarmed, the **Queen Conch** jumps jerkily along the sea floor, rocking from side to side. Cameo cutters in Italy and France import large numbers of the **Cameo Helmet Shell** (lower left). Between two purplish tentacles protrudes the mouth tube, which sheathes a band or tongue set with tiny, filelike teeth that grind up fleshy food and drill holes in the shells of prey. A **Great Sea Star** (right) crawls on the white sand. Clinging to the Gorgonian or "sea bush" (left) are two **Swollen Egg Shells** (center) and three **Spindle Egg Shells** (at sides).



GRAB THIS GAMY ARMORED KNIGHT AT YOUR PERIL!

Although the **Spiny Lobster**, or **Crayfish**, of Florida and the West Indies has no pincer claws, as does its northern cousin, long, lancelike antennae and sharp spines help protect it against enemies. During the day this brightly banded creature lurks in crevices, but at night it wanders about in search of food, pointed tips of slender legs barely touching the bottom. Its jointed tail contains delicious meat. Needlelike spines of the **Sea Urchin** (upper left) seldom stop waving back and forth on ball-and-socket joints. When the points pierce a bather's leg, they break off, work inward, and cause festering sores. Red-striped **Squirrelfish** swim above the crayfish, and red **Fire Sponges** brighten the coral.



OYSTERS GROW ON TREES IN SOUTHERN MANGROVE SWAMPS

Named for the raccoons that relish them, **Coon Oysters** cluster about and cling to side roots of the **Common Mangrove**. Running over the oysters in search of worms and small mollusks is a **Mangrove Crab**, with long jointed legs and menacing claws. When covered by the flood tide, the **Spotted Cowry** (upper center) pushes out from the slit in its pear-shaped shell a resplendent mantle which polishes and enamels its outside surface. The animal slides forward on its brightly colored foot and explores with two waving tentacles equipped with eyes. A **Mud Crab** lingers in the foreground.



LAND CRABS MAKE ANNUAL PILGRIMAGES TO THE SEA

Marching in vast armies, the black or blue **Mountain Crab** (upper right) and the **White** (lower left), of the Bahamas and southern Florida, swarm down to the water each May to spawn. No obstacle seems to deter them; they have been known to crawl through and over houses that stood in their line of march. Eggs hatch in the sea, and soon a young army follows the parental horde landward. The **Land Hermit Crab**, also abundant in the Tropics, utilizes shells and even broken clay pipes to protect its soft abdomen. One, pipe and all, is now in the American Museum of Natural History in New York.



MANY SPONGES OF FLORIDA AND THE BAHAMAS GROW TO STARTLING SIZE AND SHAPE

When alive, the **Commercial Sponge** (right) is usually dark, even coal black. From the one pictured, a **Sponge Crab** has cut a slice to serve as an "overcoat" camouflage. Many tropical sponges, like relatives in northern waters, have no commercial value because of glassy needles embedded in their tissues. Among these are the **Spiny Tube** (upper), the **Red Branched**, and the gray and green **Encrusting** forms in the foreground. Brilliant red **Fire Sponges** grow over dead coral. The **Hydroid Coral** overgrows a dead "sea bush." Its whitish filaments sting if they touch human skin.



CRABS, SCAVENGERS OF THE SEA, ABOUND IN CRACKS AND POOLS

Engaged in a sparring match are **Green Crabs** (foreground) on the rocky coast of Maine. Unlike the **Rock Crab** (upper left), and the **Jonah**, crouching in a crevice at the right, the green variety is not edible. These two are the "hard-shells" of Boston and Newport markets. Young of the tall **Sea Potato**, or "sea squirt" (left), swim about when first hatched like tadpoles. Below is a clump of **Irish Moss**, from which a table jelly is made. **Pink-hearted Hydroids** cluster in the right center.



MYRIAD SEA PLANTS AND ANIMALS LIVE IN THIS POOL LEFT BY THE RECEDING TIDE

Under a ledge scores of **Dog Whelks** feed on **Black Mussels**. From the former is produced a purple dye, once used by Indians; egg cases appear at the top. White shells of **Rock Barnacles** grow between and upon the mussels. A flat, oval **Limpet** adheres to the ledge (upper right), while to the masses of **Rockweed** below **Moss Animals** cling. The fronds also are adorned with branching **Hydroids** and daisylike **Sea Anemones**. Climbing up the **Knotted Rockweed** (left) is a **Lesser Periwinkle** and above it is fluffy **Pompon Weed**. From behind comes a "buckie," or **Furbelowed Whelk**, searching for **Horse Mussels** beneath feathery **Pink Coralline**. The urn-shaped body is a **Sea Peach**.



SEA STARS, LIKE SKY STARS, VARY IN SIZE AND BRILLIANCY IN THE GULF OF MAINE

Most conspicuous is the red and white **Sunburst Star** with arms "radiating." Beyond it is a common **Sun Star** with 10 arms. The red **Phrygian Sea Star** (lower left), has short, stumpy arms. This and the brown **Crisp Sea Star** (left center) are usually found in water of 10 fathoms or more. Most abundant are the **Common Starfish** and **Forbes's Sea Star**, several of which, varying in color, sprawl to the left. On kelp fronds waving above crawl two small **Red Stars**. **Sea Chrysanthemums** display petal-like tentacles on the mound (right). Just below are two **White-armed Anemones**. Slender arms squirming, a **Brittle Star** (lower right) crawls to shelter. **Green Sea Urchins** in the foreground.



SWIMMERS AND BURROWERS LIVE IN SANDY MUD FLATS SOUTH OF CAPE COD

Two pink **Beakthrowers**, disturbed by a fat, bluish **Clamworm**, dart spiral fashion to safety. One sticks out its club-shaped "tongue" at the intruder. Behind them a **Fan Worm** suddenly spreads its delicate plumes like a peacock's tail. Peering from chimneys, **Red-plumed Worms** (center) with lance-like feelers resemble medieval knights. A brown **Scale Worm** crawls over rockweed fronds. Just beneath is an **Ornate Worm**. Gay-hued **Sea Worms** on a pebble in front of the eel grass are magnified in the opposite plate.



UNDER A MAGNIFYING GLASS, A SEA WORM METROPOLIS RISES ON A TINY PEBBLE

Petal-like breathing organs give the **Sea Dianthus** (foreground) the appearance of a spreading flower head. Each plume has tiny eyes so sensitive to light that, when a shadow passes, the "flower" pops into the tube. Crowned with golden "piano keys," **Sand Builders** (upper and lower left) carefully wall themselves in with sand grains. Grayish tentacles protruding like "whiskers" are covered with a sticky substance that catches bits of food. Shells of thousands of **Bryozoa**, or **Moss Animals**, and **Hydroids** blanket the background. **Swallow-tail Protozoa** extend Y-shaped lappets (lower right).



PUT ON A HELMET, GO DOWN AND MARVEL AT THE LIFE ON AN OLD WHARF PILE!

These colorful creatures pump in water, from which they extract food. Yellow **Sea Grapes** (top) are related to the backboned animals. A colony of **Snowy Tunicates** is the white patch below, and the rosy mounds (right) are **Sea Pork**. Near the bottom are large yellow, transparent **Sea Vases** with long, extended siphons. To seaweed cling green **Sea Beads**. Left, working downward, are clusters of **Horse Mussels**, pink-hearted **Hydroids**, **Redbeard Sponges**, and the **Sea Dianthus** worm (Plate V). In contrast to these stationary creatures are shown **Sea Anemones**, that move slowly, a purple **Sea Star**, which crawls, a **Jellyfish**, which drifts aimlessly, and the **Squid** and **Cunner**, which dart swiftly.



LIKE KNIGHTS OF OLD, LOBSTERS, HEAVILY ARMORED, LOVE A FIGHT

The **American Lobster** ranges from Nova Scotia to Long Island. Usually one claw is heavier than the other and equipped with knobs for crushing (upper right). The cutting claw has a sharper edge with small teeth. Eyes are mounted on stalks and may be turned in any direction. The first two of its four pairs of walking legs bear small pincers. Underneath the body, forward, are the gills, and, farther back, the tiny, oarlike swimmerets. Most powerful organ is its jointed tail, which, when bent suddenly forward, shoots the lobster backward. When a female carries eggs on her swimmerets, she is "in berry" and illegal for capture. Slender feelers give lobsters a keen sense of smell.



TROPICAL SPONGES OF BATHROOM USE HAVE RELATIVES IN NORTHERN WATERS

But they have no commercial value. Through pores water is sucked in and food filtered out. Waste water is then ejected through a chimneylike opening, the osculum. Most sponges are made up of many individuals welded together. Common in New England tidal pools is the **Crumb-of-bread Sponge** (upper background). Near it is a pink **Eyed Finger Sponge**. Waving weirdly below is a pale **Dead-man's-fingers Sponge**. Brilliant **Redheards** frequent the shallows, and yellow **Sulphurs** (left) cling to stones. Tube-shaped sponges grow on dead mussels (foreground).

matlike layers of the several blue and green species, enliven the surface of dead coral rock with patches of bright hues.

The true commercial sponges, however, when alive, probably never would be recognized by one not familiar with them in this condition. They are of very somber colors, from yellowish gray through various shades of brown to coal black. In fact, some of the finest and most valuable varieties resemble masses of coal-black leather or rubber rather than anything else.

HOW A SPONGE CRAB HIDES

Most of them belong to two main genera, *Euspongia* and *Hippospongia*. *Euspongia officinalis* is shown in the Color Plate on page 316.

In this picture is shown a bit of action characteristic of a queer creature.

A sponge crab (*Dromidia antillensis*) has cut off a piece of the sponge and is holding it over its back by means of its hind claws. The crab then neatly subsides into the hollow of the sponge from which the piece was cut, as if under a trap door, and is immediately and protectively concealed by this bit of camouflage!

The commercial sponge, as seen in the market, is merely the skeletal network by which the gelatinous animal tissues of the sponge are supported and held in shape. Of silken texture, it is composed of a fibrous, somewhat elastic substance known as spongin.

The best commercial sponges have compressibility and resiliency to the highest degree, and also the added features of velvety softness and freedom from accumulated particles of hard foreign matter. The best sponges are also durable and evenly rounded or oval in shape.

When alive, the skeleton is embedded in a living tissue which has much the consistency of liver. Some sponges are massive and others are cup-shaped. Still others are welded clusters of fingerlike tubes.

The finest commercial sponges are those of the Mediterranean, but certain varieties fished on the Bahama and Florida banks are of excellent quality. The best American sponges are the sheep's-wool, velvet, and Florida yellow. Fleets of sponging schooners carry the fishermen out to the banks, and the sponges are obtained by diving or "hooking" (page 294).

The latter method, used generally on the Bahama banks, consists of spotting the

sponges through a water glass, then lowering a long-handled hook with two or three prongs to dislodge the sponge. The boats are filled with them, and as much of the animal material as possible is beaten off against the gunwales of the boat with wooden bats. The sponges are then allowed to decay in the sun, and more of the ill-smelling soft tissue is beaten away.

They are then heaped in "crawls," wicker enclosures built in the edge of the water near the shore. The macerating process is advanced and cleansing completed by more beating and rinsing.

The catch is dried aboard the boat while the fishermen are returning to the sponge market. In the market it is sorted and spread out in long sheds to be auctioned off to sponge merchants. It is then taken to sponge houses to be shaped, trimmed, and sorted for sale to the trade throughout the country (page 304).

ONLY THE FITTEST AND FIERCEST SURVIVE IN UNDERSEA WARFARE

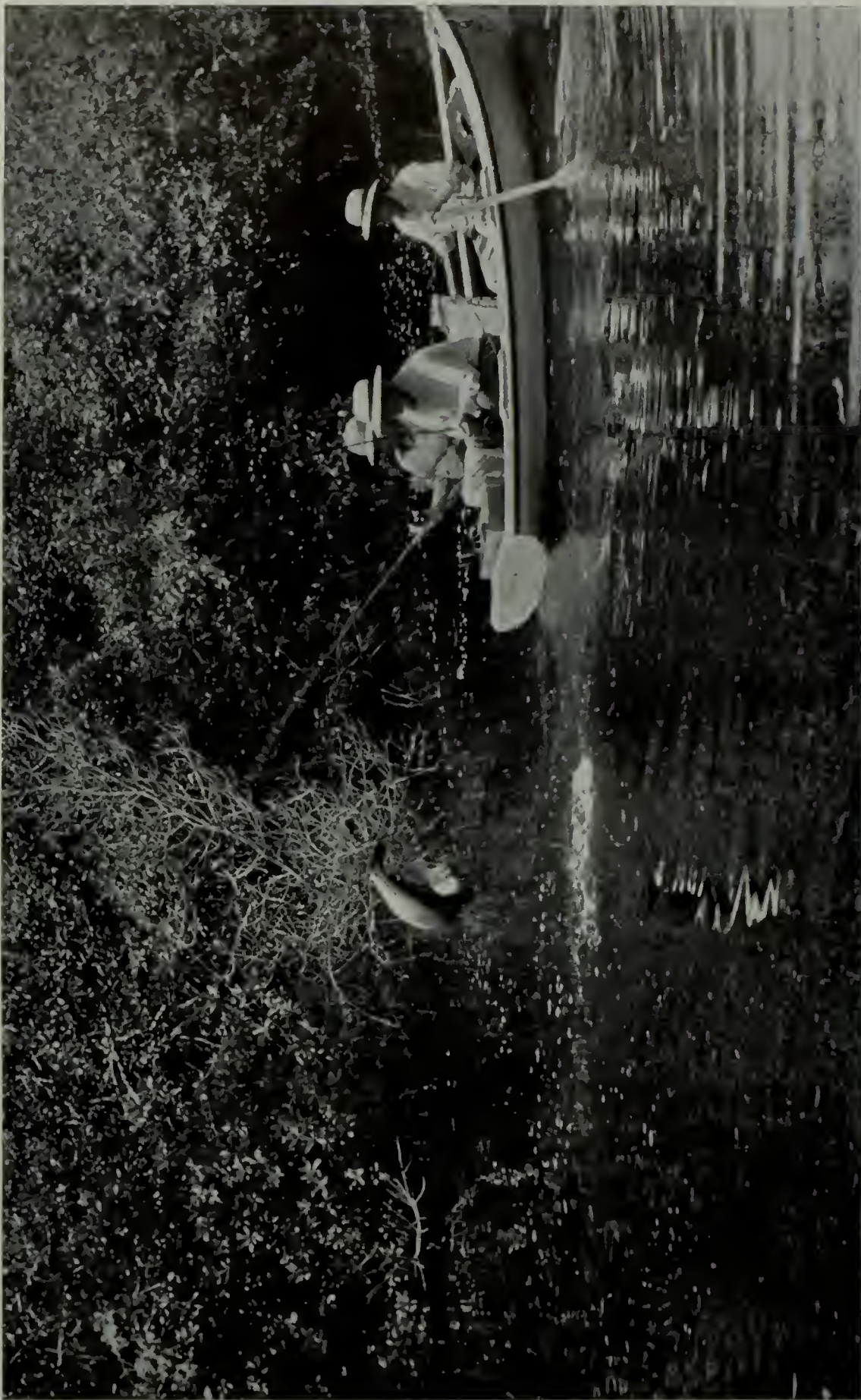
These are only a few examples of the multitudinous forms of life that swarm in the shallow waters along the ocean margin.

In the more southern waters, genial temperatures the year round allow continuous development of myriad creatures not adapted to northern seas, while an abundance of lime-producing organisms makes possible the construction of skeletal substances and protective shells to a degree not attainable elsewhere. Consequently coral reefs abound and the shell-building mollusks have reached an unusual degree of development.

Nevertheless, the same fundamental principle of interdependent relationship of all life remains. Conditions of temperature, essential chemical elements, and sunlight determine the abundance of plant life, whether microscopic or of larger growth.

In describing the constant warfare of species in the world under the sea, one might apply in reverse the principle of the old bit of doggerel, "Little bugs have smaller bugs upon their backs to bite 'em; And smaller bugs have smaller bugs; And so *ad infinitum*."

The basic submarine pasturage feeds hosts of the smaller animals, which in turn serve as food for larger forms. The process goes on endlessly in obedience to the sea's inexorable law that the strong shall prey on the weak and the fittest shall survive.



Photograph by Russell Ervin

"BABY" TARPON GENERALLY STRIKE WITH BULLETLIKE SPEED AND IMPACT

In Cuba, the tarpon is called *sabalo*. This sturdy acrobat in one of the rivers on the south coast of that island must have been particularly hungry, for it could not wait for the tempting lure to reach the water. As the angler was letting out his line, he got an unexpected strike. The fish have been known to jump into boats and create havoc as they thresh about in furious efforts to shake themselves free of the hook.

THE LORDLY TARPON

Among Islands and Passes of Our South Atlantic Shores, the Mighty "Silver King" Offers Battle

BY VAN CAMPEN HEILNER

Field Representative, Department of Ichthyology, American Museum of Natural History

THE tarpon or *sabalo* (*Tarpon atlanticus*) has often been called the angler's delight. He is one of the world's best known and most spectacular fishes. His stuffed skin adorns the walls of countless clubs and sportsmen's retreats, and his portrait in oils has graced the cover of many a magazine.

Although few realize it, to him is due no small amount of credit for the development of Florida, though he is by no means confined to that peninsula. Two world's record fish have been taken in Mexico. He is the original big game fish, anglers having come from each of the five continents in search of him long before sailfish, marlin, or tuna were heard of as game fish.

TARPON AS FAR NORTH AS LONG ISLAND

Largest of the herring family, the tarpon is more or less common from offshore Long Island (summer) to Brazil. Occasional tarpon wander north along the Atlantic seaboard every summer and are frequently caught in nets, infrequently by anglers. At Hatteras, North Carolina, the fish are present throughout all the warm months, a fact due no doubt to the close proximity of the Gulf Stream edge which at this point is only ten miles offshore. Breder mentions that off Cape Hatteras exists the greatest concentration of flying fish on the entire Atlantic Coast and undoubtedly sailfish and marlin are there as well. Although the writer has seen and caught very small tarpon up the rivers of the west coast of Florida, he does not believe that they breed north of Cuba, or if so, rarely.

Wherever they occur, tarpon are eagerly sought by anglers. As a food fish they leave much to be desired, although in Cuba the natives salt and smoke all they can get. But as furnishers of spectacular sport, when taken on the proper tackle, they have few equals.

Most of the tarpon clubs are in Florida, though a number flourish in Texas and Mexico and there is a famous club in the Canal Zone. Here where the great Gatun

Dam spans the Chagres River is to be found some of the finest tarpon fishing known.

I see no reason why the tarpon should not flourish in the Pacific, especially on the west coast of Central America, if introduced into those waters from the Atlantic side. Other fish have been transplanted from the Atlantic to the Pacific with success, notably the striped bass (*Morone saxatilis*) from the Shrewsbury and Navesink Rivers, New Jersey, in 1879 to California, where it is now more abundant than on the Atlantic Coast.

The tarpon loves to frequent passes, channels, and cuts through the banks. Here he lies in wait for whatever small fishes the tides will bring him. He can be caught either by trolling or still-fishing, and the writer has taken young tarpon on salmon flies.

ANGLING FOR THE BIG FELLOWS

In trolling, a baited hook or artificial bait is trailed slowly from a launch or skiff back and forth through the passes known to be used by the fish. In still fishing, a hook baited with crab or cut bait is lowered to the bottom and sufficient time given the tarpon to swallow the bait before setting the hook.

The instant the fish feels the point of the hook, he at once rushes to the surface and hurls himself into the air in an amazing and sensational series of leaps in a frequently successful effort to free himself. So violent and furious are these jumps that the fish finally exhausts himself and, if he does not throw the hook or break the line, is brought to boat.

There are, however, exceptions to this rule of battle. One of the largest tarpon of which I have any record, taken by the late L. P. Schutt of the Long Key Florida Fishing Camp, jumped only once during the entire fight. At the end, as the fish was almost to boat, a large shark rushed up and bit it in two just behind the dorsal fin. The part remaining, which weighed more



© Erl Roman

A 40-POUND TARPON MAKES A 10-FOOT LEAP

How high-jump records would be shattered if a man could do as well for his size and weight! Hooked on an artificial lure with bait rod and 12-pound-test silk line, this gamester of Tarpon Basin, in the Shark River, Florida, put up a magnificent exhibition.

than two hundred pounds, was mounted and hung for years in the Lodge at Long Key until the building was destroyed in the hurricane of 1935.

In Florida, the best tarpon fishing occurs in May and June. Earlier in the season the fish are frequently caught along the viaducts of the Florida East Coast Railway, now a highway, but at that time of year they seem to strike best at night.

Curiously enough, in many trips to Cuba, I found the tarpon take the bait best between nine in the morning and four in the afternoon. Later or earlier than that it was almost impossible to get a strike.

I have seen the tarpon around Florida's Cape Sable lying all over the shallow flats and banks like shoals of bait and in the harbor mouth at Bimini in the Bahamas, about 50 miles across the Gulf Stream from Miami Beach, there are at all times

large numbers of young tarpon weighing from thirty to fifty pounds. These, which are clearly visible through a water glass, lie on the bottom almost as thick as sardines in a can.

BIGGEST THRILL—THE FIRST FISH

I first became interested in the tarpon through the enthusiasm of my late friend Anthony W. Dimock, father of Julian Dimock. Father and son, great sportsmen and students of marine life, took the finest photographs of leaping tarpon ever made.

My first tarpon weighed only twenty pounds, but if he had weighed two hundred, my excitement and delight could not have been greater. The circumstances remain engraved upon my memory. A moonlight night, the ghostly arches of the Florida East Coast viaduct, the putt-putt of the tiny launch that carried me cross-



Photograph by Van Campen Heilner

FOR BREAKFAST THE JUNGLE RANCHER POLES OUT TO SPEAR A VIAJACA

Quiet rivers in Cuba teem with this species of food fish, which, though rather small, is delicious when properly cooked. Though the streams offer excellent opportunities for tarpon fishing, residents of the region seldom indulge in that sport.

wise to the rushing tide; then the strike and the flash of silver, dripping diamonds of spray from its flanks as it catapulted into the air again and again, and yet again. A lot of water has flowed through those arches since that time and many a tarpon has leaped at the end of my line, but that first one I shall never forget.

I remember one blazing hot day toward the end of March on the vast miles of banks off the southern tip of Florida. The tide had turned to the flood about three in the afternoon, and all along the vast shoal from Sandy Key eastward to Snake Bight tarpon were rolling. The mullet were "in" and the water was discolored a milky white.

As we slid across the flats in our little skiff propelled by an outboard motor, we could see the long plumes of tarpon wavering for an instant on the surface. The

sun had just set in a great ball of red fire as we started up a long, blue-green channel that wound between the banks. I was fishing with an extra light outfit, a rod that weighed only four and a half ounces over all and was more suitable for fresh water gamesters than for tarpon.

We came to the end of the channel and turned to retrace our wake. Suddenly there was a swift surge on my line. I struck, and into the air bounded a tarpon.

I could hear the tinkle of the spoon as he wrestled his head from side to side in an effort to dislodge the hook. But it held, and this seemed to increase his frenzy, for he was in and out of the water so fast that I wondered if I was fast to some great sea-bird or a fish that preferred air to its natural element.

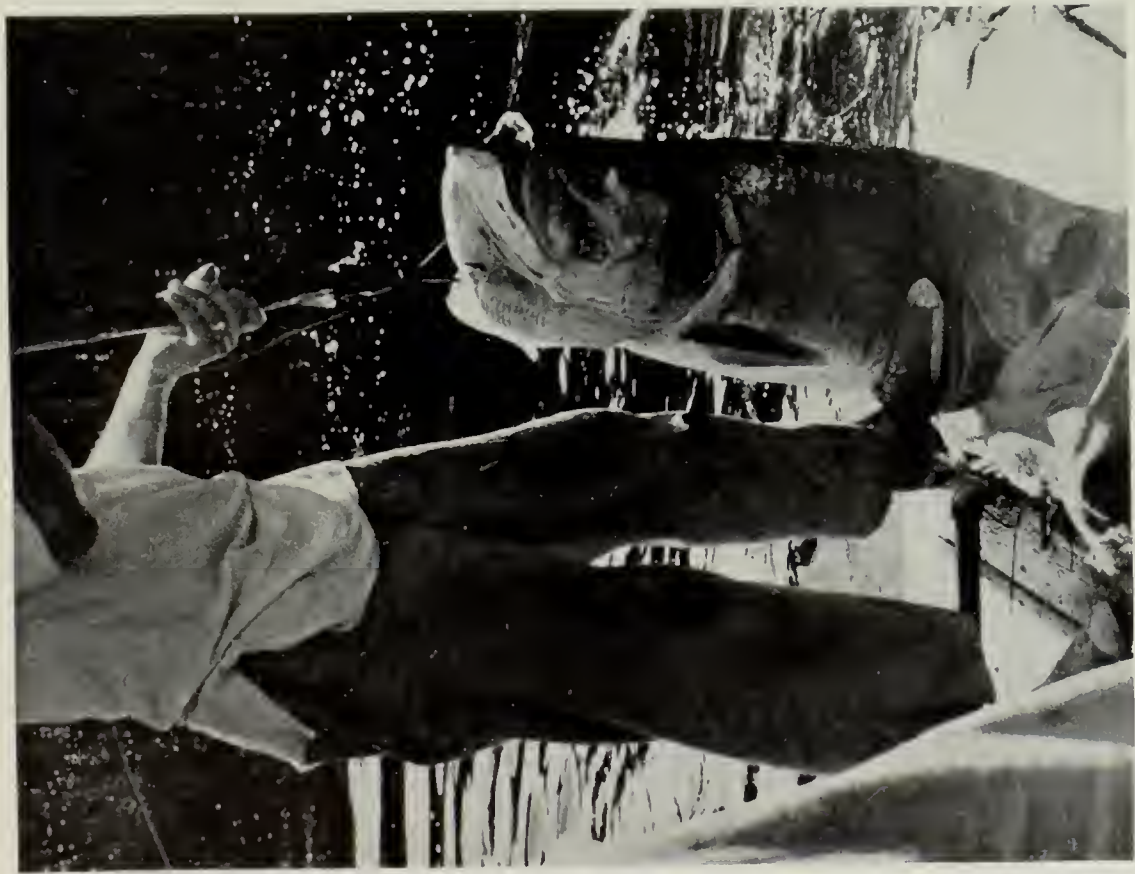
The skiff drifted with the tide, and the fish continued its mad leaping. Half the



Photograph by Van Campen Heilner

IN THE HEART OF A CUBAN JUNGLE, A CHARCOAL BURNER'S CAMP WAS THE FISHERMEN'S BASE

"Tarpon abundant and eager to strike!" was the report the author brought back from an exploratory trip to certain small, remote rivers of southern Cuba. The pile of wood in the background is ready for the kiln. Though the flesh of the sabalo is generally considered not palatable, the natives sometimes use it as food.



WORN OUT AT LAST, THE PRIZE IS BOATED

In trolling for these big fellows, a baited hook or artificial bait is trailed slowly back and forth past the fish's haunts.



Photographs by Van Camper Helmer

THE CAPTIVE IS ALMOST AS LARGE AS THE CAPTOR

When a sportsman with light tackle conquers a big beauty like this satalo from the Rio Encantado, Cuba, he has earned his prize.



Photograph by Anthony V. Ragusin

TWIN "SILVER KINGS" AND A QUEEN

Taken in the same hour in the main Biloxi channel just off the Old Spanish Trail boulevard in Mississippi, this fine pair was kept to adorn a clubhouse wall. Among channels and islands of the Gulf Coast, tarpon are caught in considerable numbers during a long fishing season from May to November. In October the sea fighters "school up" and then, anglers say, thousands have been seen in a single school. Near Pass Christian is a famous tarpon-fishing hole.

time I did not know whether I had him on or not. But then the line would straighten out and the dead weight would come at the end and I knew the fight was not yet finished. The tackle was so light that I could not easily force the fighting, and it was more than a half hour before I had him alongside.

He was worn out from his terrific exertions. We tipped the skiff down on one side and slid him over the edge into the boat. He weighed 56 pounds and even today adorns the walls of my studio, one of my proudest achievements with rod and line. For thrills aplenty, try the "silver king" on bait-casting tackle!

TARPON ARE CAUGHT AND RELEASED

I remember another day in June on the West Coast of Florida. We were still-fishing in a pass. Tarpon had been rolling all around us, but we could not tempt them to bite. I was drowsing in my seat at the stern of the skiff, when suddenly I noticed the line, which I had stripped from my reel and laid on one of the thwarts,

start to uncoil and slide over the edge into the sea. For several seconds I watched, fascinated; when it had almost reached the end, I let it come taut and struck, once—twice. Immediately a tarpon shot skyward astern and a little to one side, and the battle was on. From then on, tarpon bit at anything and everything offered, and in a brief time we boated and released seven.

So it goes. A friend, B. W. Crowninshield, brought to boat 25 tarpon between sun-up and sun-down at Boca Grande, the famous Florida West Coast resort of these mighty fish. In Cuba we have hooked and jumped as many as 104 fish in one day.

About three out of every four tarpon throw the hook on their first leap. As a rule they run from thirty to eighty pounds. Many are caught weighing from 120 to 170 pounds. These are large fish. A specimen of 200 pounds is exceptional. The present world's record was taken by Jax. M. Cowden in the Pánuco River, Mexico. It tipped the beam at 242 pounds, topping by ten pounds the record held for so many



BY WAY OF VARIETY, THE TARPON TRIES A BACKWARD SOMERSAULT

The stream is narrow, and both banks are heavily wooded. At any moment a spectacular leap may carry the big fish into the bushes.



Photographs by Van Campen Heilner

LIKE A LIGHTNING FLASH IS THE LEAP OF A SABALO

One giant warrior from the school swimming in the background has taken the hook, and the battle begins with this mad lunge out of the water.



Photograph by Russell Ervin

WHEN A BIG ONE JUMPS CLOSE, THE SPORTSMEN GET SPLASHED

From mangrove shadows tarpon dart to seize the lure. Dark streams bordered by thick bushes are favorite lurking places for these huge fish. Once the angler gets a strike, he is in for a fight at close quarters.

years by W. A. McLaren with a fish taken in the same locality. We have a mounted tarpon in the Museum, details of capture unknown, which from appearances must have been close to three hundred pounds. This I should think is about the limit of heft for this species.

TARPON MAY SPAWN IN FLORIDA RIVERS

Tarpon probably spawn somewhere in the Caribbean, possibly up brackish or fresh-water rivers from which they descend to the sea and wander all over. I have always felt, though I could never prove, that some must spawn up the rivers of the West Coast of Florida; I have seen countless baby tarpon in these streams and in the ditches along the Tamiami Trail. Very tiny tarpon, only a few inches long, have been taken in Puerto Rico and Cuba,

and the chances are that the main spawning grounds are below the Tropic of Cancer.

There is no doubt that the majority of tarpon seen run from thirty to eighty pounds. Where the big ones keep themselves is a question. It occurs to the writer that as tarpon grow larger and older they lose some of their agility and more easily fall prey to sharks. Of course there are plenty of big tarpon still left, but the smaller ones outnumber them five and six to one. The shark theory is at least plausible.

For several years the writer has been carrying on exploratory work in the swamps and rivers of southern Cuba. This country is well nigh inaccessible and can be reached only after arduous travel on horseback and afoot through almost impenetrable swamps. Many of the rivers literally



Photograph from Van Campen Heilner

FROM A NARROW CUBAN STREAM, A HOOKED TARPON MAY JUMP INTO THE TREES
Fishing where forest growth crowds the water presents unusual difficulties for the sportsman.



Photograph by Van Campen Heilner

FURY RAGES OVER THE WATERS

In herculean efforts to shake itself free, the mighty opponent is almost as often above as below the surface. It lashes the quiet stream into foam and whirls like a circus aerialist.



Photograph by Russell Ervin

WITH A COMPLETE FLIP-FLOP, THE "SILVER KING" LASHES THE WATER INTO SPRAY

Only light tackle is used by the true sportsman in his battle with this dauntless gamester. Unless the fish is injured in the terrific struggle, it will be released as soon as it has been brought to boat.

swarm with tarpon which have never even seen man. They will strike at any moving object.

The rivers are dark and narrow, and the mangrove bushes crowd them closely on both sides. The water extends in under the bushes for some distance, and, as one passes, the tarpon (or sabalo, as they are called there) rush out from beneath the overhanging branches and seize the lure.

ONE MIGHT LAND IN THE BOAT!

Quite frequently their first leap lands them in the trees, from which they fall with a great crashing and breaking of branches into the water, leaving the angler's line a tangled mass above. Several of the photographs accompanying this article are

the result of three years of fishing on these Cuban rivers. Though no sabalo ever actually landed in the boat, two or three of them came mighty close to it. If a fish should actually land in a fishing boat—the accident has occurred on one or two occasions—the results might easily prove disastrous.

If you love angling, and want some of the most spectacular sport to be found, pack your tackle and make your plans next spring to slip down the coast to Florida, or Texas, or Panama, or any one of countless other places that fringe the Caribbean. There you may try your mettle on one of God's grandest gifts to fishermen, that bow of flashing silver, that master of aerial acrobatics, the leaping tarpon.

MARKET FISH HAVE MANY NAMES

Between the Fisherman's Net and the Customer's Table Appear Many Finny Aliases and Doubles

BY RUSSELL MALONEY

IT'S A wise diner who really knows what kind of fish he is eating.

However widely varied the menu of a restaurant may be, you will seldom find more than six or eight fish listed; yet every day, eighty to a hundred varieties are offered by the wholesalers in New York's great fish markets.

The explanation of this state of affairs is twofold: Many fish are eaten by only one race or nationality, and so are unknown in ordinary neighborhood fish-markets; other fish mysteriously change their identity somewhere between the fisherman's net and your table, substituting for a fish that may be out of season at the time, or more expensive.

I realized how little the average person knows about the fish he eats when a buyer for one of the big Eastern fish-dealers let me go with him on his morning rounds, and told me what happens to some of the less-known varieties.

Pointing to a bin of mullet, my guide told me that, though it is highly regarded in the South, there would be no demand for it in New York except among the Italians and the Harlem negroes.

"Italians are the only people who really know about fish," he remarked. "They'll eat anything that comes out of the water."

He mentioned two other fish popular only among the Southern-trained colored folk: catfish (which they all say is sweet as chicken), and spot, known in other regions as Virginia spot, Cape May goodies, or Lafayettes.

EACH FISH IN ITS TIME PLAYS MANY PARTS

The eating of skate, a close relative of the shark, is confined mostly to the French and Italians. Warsaws, crappies, muttonfish, and groupers appear more frequently in the Chinese cuisine. The Latin and Oriental races are the chief buyers of conger, deep-sea, and common eels, and of squid and octopus. Except for brook and rainbow trout, Jews eat most of the fresh-water fish sold in New York: freshwater mullet, whitefish, lake herring, yellow perch, and the different kinds of pike.

These racial specialties, then, account for about half the unfamiliar fish to be found in the wholesale market. The remaining fish, my friend told me, have not so blameless a story.

Fish with aliases enter the picture, and fish with doubles. The porgy, for example, has both. It is known as scup in New England, porgy in New York, fair maid farther south, and once more as porgy in Charleston; but, wherever you order it, you're likely to be served the less expensive sheephead.

My friend was careful to point out, however, that such deceptions are practiced only by unscrupulous restaurants and retail fish-markets. At the large New York markets the fish are all called by their proper names, and fairly priced.

"SOLE" MAY BE ALMOST ANYTHING

Your fillet of sole is likely to be almost anything *but* fillet of sole—fillet of had-dock, yellowtail, halibut, fluke, flounder, dab, or any other fish that can be filleted. There is, strictly speaking, no such thing as American sole, and the real thing costs about forty-five cents a pound imported frozen from England.

Boston scrod, which should of course be young cod, may instead actually be had-dock. As for pompano, which is so popular with gourmets, it is all mixed up with the runner (also known as amberjack or coronado), the butterfish, and the angelfish.

The runner has two little fins which distinguish it from the pompano, and it is a regrettable fact that unscrupulous fish-dealers sometimes clip a runner's wings and sell it for a pompano. It is hard to detect the difference in flavor.

Another inexpensive fish that can be served as pompano is the butterfish. The angelfish stands in the same relation to the butterfish as the runner to the pompano, costs much less, looks the same with its fins clipped, and has a similar taste.

Stopping at a bin of weakfish, my guide told me that this fish, known in New England as the drummer and as squeteague or gray trout in the South, appears on many



© International News

HALF OF THE FRESH FISH USED IN THIS COUNTRY COMES TO FULTON FISH MARKET

Only Billingsgate in London handles a greater harvest of the sea than the huge New York City establishment, which averages 500 million pounds a year.

restaurant menus as sea trout. Most cooks don't even know that there is a true sea trout, which lives in salt water and occasionally comes up into inland streams.

Many inland people perhaps have never heard of the pollock, but they've eaten it under the name of Boston or deep-sea bluefish. It also doubles for cod and haddock. Other substitutes for cod are cusk and tilefish. Pollock and mackerel roe are both economical substitutes for shad roe. The cost is a small fraction of that of genuine shad roe.

"As for caviar," my mentor said, "it is not always what it seems. You know that small, black caviar they offer you on crackers at swell bars? That's usually whitefish roe, colored with powdered charcoal.

"Of course," he hastened to add, "powdered charcoal isn't bad for you. Doctors sometimes prescribe it for indigestion."

The red caviar sold in this country is salted and pasteurized salmon roe. The spoonbill cat, or paddlefish, a native of the Mississippi River, produces an acceptable

caviar, greenish-black in color. There is virtually no first-class domestic caviar to be had these days in commercial quantity.

As late as 1900, fishermen were catching two or three million pounds of sturgeon annually in the Delaware River, and exporting the caviar at the modest price of \$105 for a 135-pound cask. At the present prices such a cask would fetch \$2,000. Today sturgeon are almost gone from the Delaware, and while there is a small catch in the Great Lakes, the caviar is never so well prepared as the product imported from Russia.

The common herring, *Clupea harengus*, is the herring, one of the most important food fishes in the world. It sometimes substitutes for the alewife, and both herring and alewife substitute for shad. Shad, however, is so common and plentiful that you usually get it when you ask for it in season.

There are complications even among mackerel. Spanish mackerel serves as the better-known New England mackerel and vice versa. King mackerel serves as Span-



Photograph from Wide World

FULTON FISH MARKET HAS COME UP IN THE WORLD

After the collapse, in 1936, of part of the original structure, which had long been a landmark on the lower East Side, New York erected a new one on the East River just below the Brooklyn Bridge. Modern and "streamlined," it cost \$400,000. Mayor La Guardia (hat at side) accompanied Market President Michael Liebl (in light suit) on a tour of inspection in June, 1939.

ish, and bonito may be served as either Spanish or King mackerel. One variety is quite as good as another in food value, but some dealers seem afraid to give the public something with an unfamiliar name; that hurts sales.

"Take swordfish," my friend said. "You order swordfish in many places, and you get broadbill or marlin. In inexpensive Italian places, though, you might get shark."

He added, with scrupulous fairness that, though it was possible to smoke shark and sell it as sturgeon, it was doubtful that this was done to any great extent commercially.

The name Kennebec salmon, as applied to fish caught off the Atlantic coast, has degenerated to a trade term, the Kennebec River being almost fished out. Connoisseurs say that salmon from the Penobscot is the best of all. The chances are, however, that whether your menu calls the salmon Kennebec or Penobscot, it was really caught off New Brunswick.

About 75 per cent of the halibut we consume now comes from the Pacific coast. There is a closed season on it during the winter, with the result that virtually all of it served then is frozen. Both lobster meat and crab meat blend nicely with halibut. In dishes in which lobster or crab meat is prepared with a sauce—lobster Thermidor or crabmeat soufflé, for example—it is possible to mix in considerable halibut without arousing the suspicion of the hungry diner.

Some years ago a man attached to the Bureau of Fisheries in Washington, D. C., noticed that a fish sold locally under the name of sand perch looked surprisingly like goldfish. He investigated, and found that they really were goldfish!

Years before, the pools at the base of the Washington Monument had been stocked with them, and they had escaped into the Potomac one spring when the river had overflowed its banks. They bred freely in their new home, reverted to their original



Photograph by Kurt Severin from Three Lions

NEW YORK FISHING BOAT PIERS BUSTLE WITH ACTIVITY

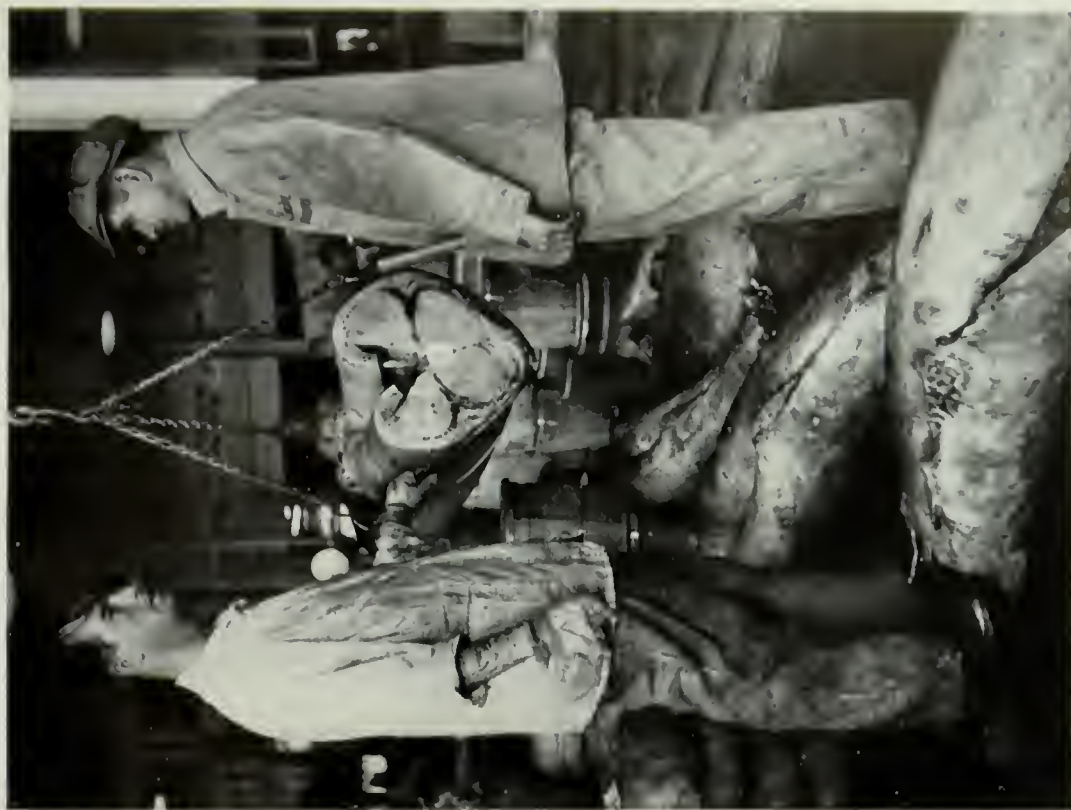
Day and night the ships come in with cargoes from near and far along the Atlantic Coast. Most of the fish are sold in the Fulton Market, where they are prepared for delivery to the retail trade. The most important fishery is the cod fishery, which has been the mainstay of the New York fishing industry for many years.



Photograph by J. Baylor Roberts

LOUISIANA CRAWFISH REACH NEW YORK BY TRUCK

Besides these rare delicacies, shrimp and Gulf fish in refrigerated carriers are rushed overland to the Fulton Fish Market in two days.



Photograph by Kurt Severin from Three Lions

GIANT SWORDFISH ARE CUT UP FOR WEIGHING

At full length they are too large for the scales. It is only in recent years that this species of fish has gained table popularity.



© International News

THERE IS GOOD FISHING NOT FAR FROM BROADWAY

Every year from late March until the end of May, the shad fishermen ply their trade on the Hudson, catching good hauls from Peekskill to a point below the George Washington Bridge. Many of them earn enough in this short season to provide a living for the rest of the year. Lively demand for both the fish and the roe has caused a heavy drain on the once countless numbers of this succulent fish, but of late years the supply has showed some tendency to increase rather than decrease.



KING COD BECOMES "FILLET OF SOLE"

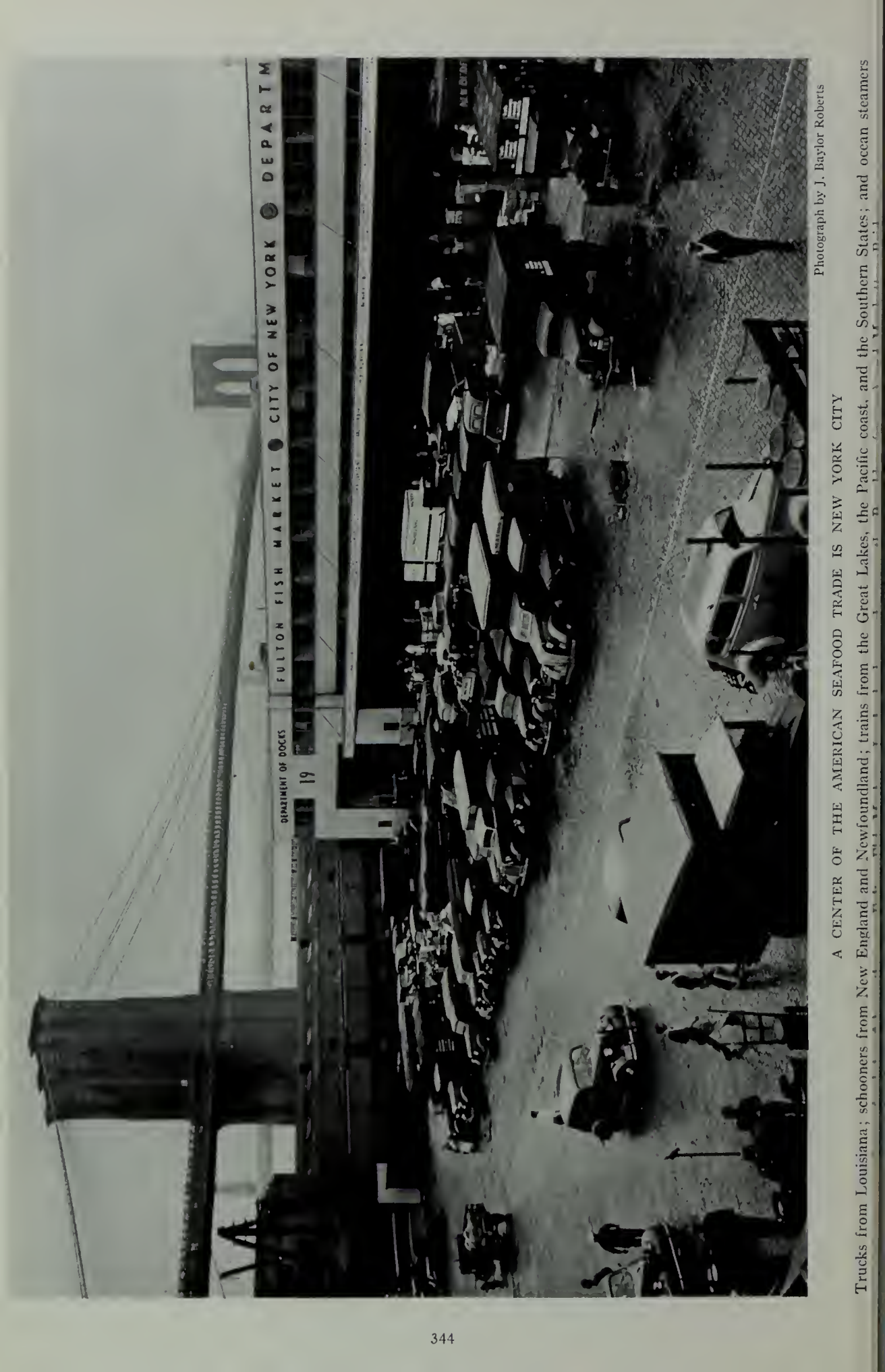
Because all genuine sole, imported from England, is very expensive, fish dealers very often cut cod and flounder into fillets to be used as a substitute. However, reputable retailers advertise and sell the fish under its proper name.



Photographs by J. Baylor Roberts

NEW YORK ITALIANS BUY CONNECTICUT CONCHS FOR SALADS

New York market dealers do a thriving, though racially restricted, business in these shellfish, which are gathered in shallow waters of the "Nutmeg State" and sold for about two dollars a bushel.



Photograph by J. Baylor Roberts

A CENTER OF THE AMERICAN SEAFOOD TRADE IS NEW YORK CITY

Trucks from Louisiana; schooners from New England and Newfoundland; trains from the Great Lakes, the Pacific coast, and the Southern States; and ocean steamers



Photograph from Wide World

DEALERS UNLOAD BLOCKS OF FROZEN FISH

Fishing boats and freighters from all along the Atlantic seaboard bring their fresh, frozen, and salted cargoes to New York City. Merchants purchase the scaly produce in large quantities, pack it according to ever-improved methods, and distribute it to retail markets.



Photograph by Ewing Ga'way

A BIG SNAPPER GOES ON THE SCALES

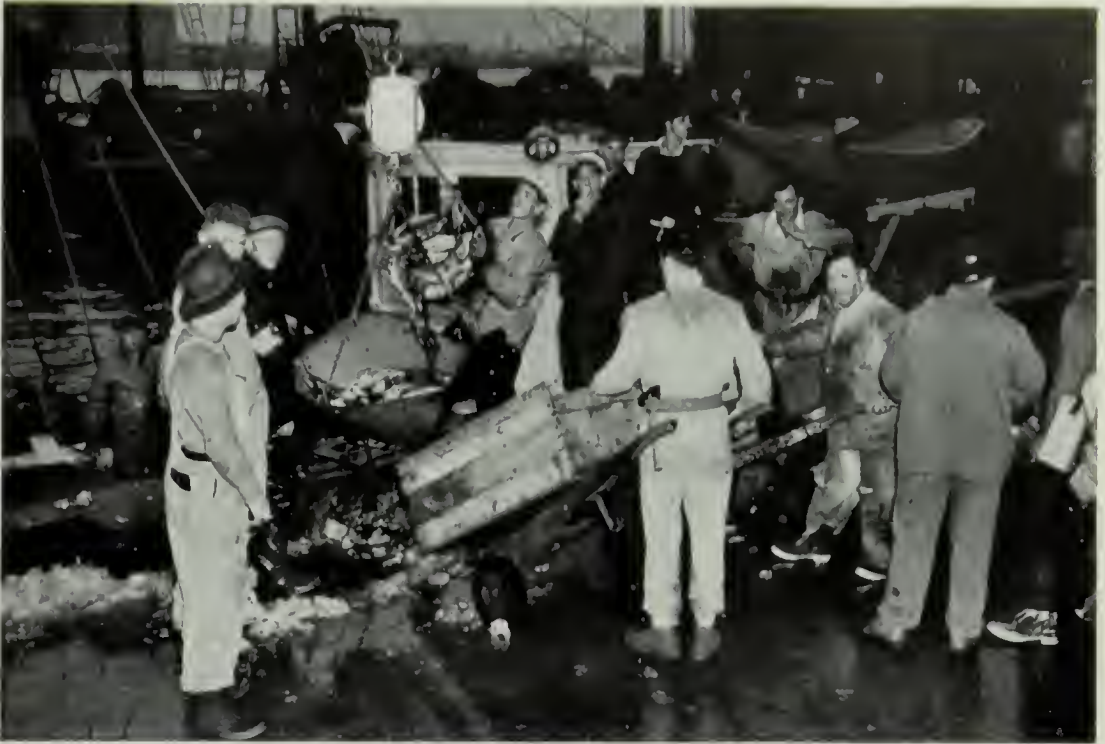
Near Fulton Market nearly all the fresh seafood eaten by the city's seven million people is unloaded from schooners and packed with ice in barrels for delivery to neighborhood shops. Fish is an important item in the New York food bill.



Photograph by Philip D. Gendreau

FISHING BOATS TIE UP IN THE SHADOW OF SKYSCRAPERS

Since New York was a tiny village, spoils of the sea have played an important part in its food supply. Many of the racial groups that compose the vast city have their favorite kinds of fish; consequently the stalls of the venders display a bewildering variety of species.



Photograph by J. Baylor Roberts

WHEN PRICES ARE RIGHT, NEW ENGLAND "BANKERS" BRING COD TO NEW YORK

Most of the fishing schooners are equipped with radio telephone by means of which they keep in touch with buyers in Fulton Market. Unloading begins just after midnight and continues until noon, when purchasing activity stops.

color, and were innocently sold by the local fishermen as "sand perch."

"Perch" of another sort are the redfish to be found along the New England coast. The redfish was not too pleasant to look at and couldn't be sold in quantity until, about ten years ago, fishermen began to fillet and sell them as red perch.

Oysters and clams cannot be faked, of course. Furthermore, all shippers, wholesalers, retailers, and restaurateurs are required to keep a register showing exactly where their oysters and clams were raised, so that the beds can be checked for sanitary reasons. The names of clams—little-neck, cherry stone, chowder, quahaug—indicate merely their sizes.

The names of oysters indicate the places where they were grown. There is one exception to this: Blue points, strictly speaking, should be natives of Sayville, Long Island, but the name now usually applies to any medium-sized oyster, wherever grown.

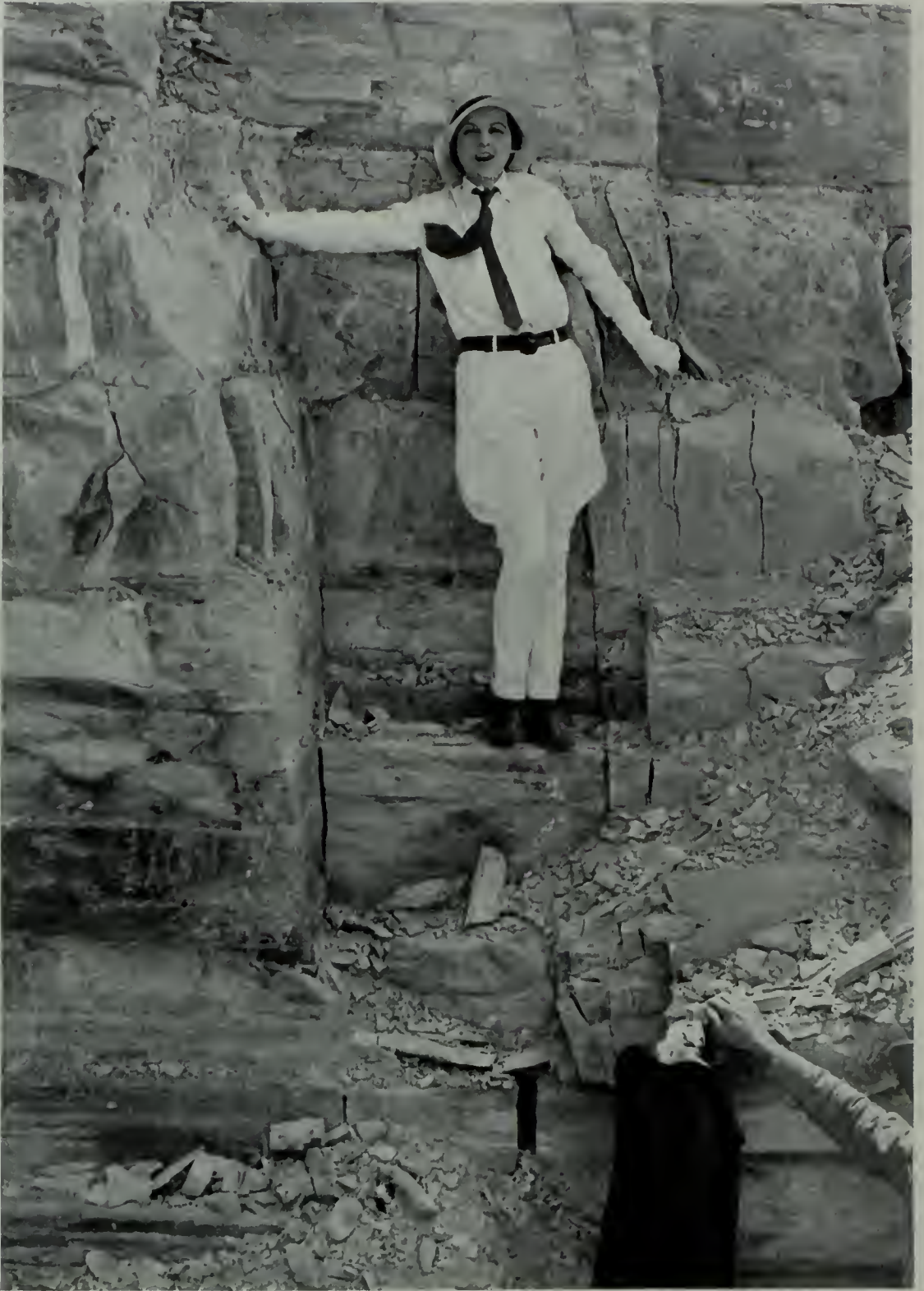
There are no restrictions applying to scallops, however, and it is a regrettable fact that chefs sometimes economize by buying the large deep-sea scallops, known also as skatewings, and cutting bits the

size of the smaller and more delicate Long Island scallop from them with a kitchen instrument like a cookie-cutter. This forgery can sometimes be detected if you know that the grain runs lengthwise in the flesh of a Long Island scallop; the skatewings are very often cut cross-grained.

Most of the fish dealers take pride in the versatility of their fish. While I was looking around a big New York market, one of them took a whiting out of a bin and gave me a brief lecture on it. It would, he said, make an excellent smoked fish, except that smoking would cause the teeth to show, giving it a bulldoggish expression.

"You'd have to cut the head off, and that would be too much trouble," he said. "But," he added, looking with affection at the fish, "you'd be surprised what I could do with this here whiting. I could sell it for a hake, a kingfish, or a small sea trout. I could fillet it and sell it as a sole. I could even sell it as a whiting."

Noticing my obvious disillusionment, he laughed genially and said, "Except for clams and oysters, there's only one thing they sell down here that can't be faked. Know what it is? Frogs' legs!"



Photograph from Imogene Powell

THE AUTHOR EXPLORES THE FOSSIL-FISHING GROUND

Many specimens of plant and animal life that flourished ages ago were buried and perfectly preserved in the ooze of a lake bed which now is this hill of stratified rock. The deposits have escaped destructive land disturbances, and erosion has made easily accessible the richest fossil area in the United States. A week-end "catch" may net a herring, bass, or some other fish, a six-foot palm leaf, a prodigious mosquito, or perhaps even an ancient 13-foot crocodile, all turned to stone (see text, page 349).

"COMPLEAT ANGLER" FISHES FOR FOSSILS

In Wyoming's Rocky Mountains Inhabitants of Ancient Seas Are "Caught" with Hammer and Chisel

BY IMOGENE POWELL

THERE is one feature of fossil fishing which sets it apart from all other angling sports—the big ones can't get away!

This fact, and also the minor one that fossil-fishing in this country must be carried on in the remote, not to say obscure, portions of the United States, will probably keep it from assuming the place which it deserves as a major American outdoor sport.

The proper fossil-fishing trip leads you, for example, to Fossil, Wyoming, where you may be the only person getting off there that year!

Now, the *Priscacara pealei* (poor fish to you!) may look tame enough as you pass him by in a museum on your way to the stuffed owls; but that is because these ancient relics of prehistoric days have been carefully caught for you, imprisoned in their stone frames, labeled, and hung where they can excite only the inflammable interest of the paleontologist.

But try fishing some time for those rovers which, only a few million years ago, "when you were a tadpole and I was a fish," swam blithely through that inland ocean where are now the Rocky Mountains.

A WEEK-END FOSSIL "CATCH"

One week-end fishing trip in Wyoming may net you a six-foot palm leaf, three large pickerel, bass, or pike, a prodigious mosquito (just the way you'd like to see a mosquito, transformed into solid rock), sun-fish, herring, the thick-scaled gar pike.

Then, you never know when you may come upon an ancient crocodile 13 feet long. One was found near the fossil bed, where you must look if you expect your week's sport to be really exciting.

Fossil, Wyoming, is formed by the accidental meeting of two roads which slipped down from opposite sides of a mountain. There is a pleasing legend that the population of Fossil is 50; but, counting the people you can see and the ones you can imagine, you cannot arrive at a generous estimate of more than 30. There are four regulation buildings, and there is a box-car fitted up with chintz curtains and bespangled with

cooking pans. The foreman of a section gang lives there. A sheep herder's summer home, neat barrel staves covered with sheeting, stands at the corner of State and Madison (page 351).

They will have to stop the train especially for you. They don't like to do it—and, as you look out over the wind-swept, cold, purple dawn on the Rocky Mountains at this particular point, neither do you.

But it's worth it!

THE FOSSIL MOUNTAIN LIES ASLEEP IN A DISTANT PAST

A few minutes after you have arrived on a well-conducted fossil-fishing trip, the sun will break over the farthest ridge in a long crescent of fossil mountain which sleeps content in a past which even the most arduous fisherman will never know.

Around you is a shallow sweep of mountain—red, gray, green, blue, and purple—colored with time and embracing earth and sky and air. The sky is a curious translucent blue. You stand as if on the basin of some huge broken piece of pottery. All about you at the broken brim are fossil beds which you may fish to heart's content and whose depth you may never plumb.

Custodian of the fossil beds, amateur sportsman extraordinary, Robert Lee Craig will take you fishing if you have an honest interest. He has been fishing in these hills for 37 years, and he has no patience with people who will not climb with him the 275 feet from his camp to the fossil hill; who will not wait while he lays bare a stratum of fossil rock; who will not, with his own suppressed excitement, cleave those strata again and again, peeling, stripping the layers down as if they were ears of corn. Often the finest specimens of fossilized fish will be hidden just beneath the gray-white surface and would pass notice of all except the most observing.

It is best to wait until midday to raise a ledge, for then the bright rays of sun, striking each layer as it is peeled off with wedge and hammer, often show up the faint tracing of a backbone, the dim outline of a fin. When this outline is revealed, the fossil



Photograph by Imogene Powell

FOSSIL-FISH STORIES CONCERN AGE RATHER THAN SIZE!

Paleontologists estimate these to be approximately 55,000,000 years old. The long, slender fish has many fossil contemporaries in the dusty mountains of Wyoming, but only one species lives to-day, in the South Pacific. The other specimen is a herring.

fisherman takes the sharp blade of a knife and gently scratches the protecting shale away to make sure of his specimen. Then he hews out a square of rock around the fish, and the specimen is ready for cleaning. The cleaning process is done with the fine blade of a knife, great skill being exercised to clear away all trace of rock in which the fish is embedded without destroying the delicate outline of the fish.

Through the years Craig has become highly skilled in this art. He waits a certain number of hours after the fish has been raised, so that the slightly damp rock will give properly to the knife blades, and yet so that sufficient air will have struck the

specimen to keep it well preserved during the process of cleaning.

To raise the strata, to cleave those gray-stone squares—most often they are about six inches thick, though some are much thicker—requires strength and a certain skill easily acquired by the amateur. But to clean fossilized fish the skill of an artist is required.

This master fisherman skins them in the record time of 20 minutes—can clean them so that the tiniest fin, the most delicate scale, will stand in bas-relief. Sometimes he scrapes away the stone around the fish so that it lies against a frame. Sometimes he cuts an irregular outline about them—each fish to its setting.

FOSSIL FISHING REQUIRES PATIENCE

If you go to Fossil to fish, you will most certainly not raise a fish the first day. That is contrary to the whole custom of fishing the world over. No, the first day must be one of disappointment—of

a long, sharp climb up barren rocks, of sliding on heaps of shale, of digging out mountains of broken rock which nighttime, winds, and a passing sheep herder have shoved down onto a layer which just the day before has been prepared for raising as if for your special benefit.

These fossil hills are contrary—jealous as deep pools where bass lie hidden from the caster's fly. They slip and slide, they shift and fall, to confound the fisherman and make for him unceasing labor. You must wait and hope, you must listen to stories of other fish, other days; you must eat your noonday sandwich dry and brittle and filled with some dust of shale; you must

know the sadness of cleaving a whole sheaf of rock at last—good, firm fossil rock in which whole schools of prehistoric fishes should lie buried—only to find it barren as a desert trail. No, these fish took one more dive before the cataclysm. They lie to windward or to leeward. And though you are some 25 or 30 feet below the top layer of protecting shale, still you have not fished deep enough.

"FISH" ON DUSTY MOUNTAIN TOPS

If you are a proper fisherman, you will of course spend many lingering moments which might otherwise be tedious in contemplation of the ancient story of how your "catch" came to be cast up, in the very act of living, onto the dry and dusty mountain tops. As a theme for meditation, it far surpasses the habits of the lively pike in his favorite deep-lake retreat. For the how and the why of the northern pike in present-day waters is mysterious enough, but the how and the why of the fossil gar pike is the story of Time itself.

Perhaps the best definition of the fossil fish for the amateur stone fisherman is the simple one given by the late Frederic A. Lucas, formerly a curator of the National Museum, in his book, "Animals of the Past."

"Fossils," he says, "are the remains, or even the indications, of animals and plants that have, through natural agencies, been buried in the earth and preserved for long periods of time." These "indications," which may be footprints, tramped leaves, the almost formless jellyfish, the very ripple



Photograph by Imogene Powell

THE COVERED WAGON IS ONE OF FOSSIL'S FEW RESIDENCES

This crossroads settlement in southwestern Wyoming, according to legend, has a population of 50, but the author estimates not more than 30. The "town" has four regulation buildings, a box-car, and a sheep herder's simple summer home on wheels.

on the sands, have been, in many instances, preserved in stone, perfect patterns of the ephemeral life of millions of years ago.

And how did fossil fish come to be imprisoned in their strangely lifelike stony form in the Rocky Mountains of Wyoming? Your mind must go back to lost ages, when an ocean rolled over the wheat fields of Kansas, the prairies of Nebraska, and the site of the Empire State Building alike. These abundant seas were ruled successively by many different races of sea creatures, which came, triumphed, and held ascendancy for their little time. In due course they were conquered by larger and more powerful species, and at last lay



Photograph by Imogene Powell

"COME ON OVER; WE THINK WE'VE GOT ONE!"

Peeling away the layers of this slab may reveal a rare fossil prize or be as fruitless as whipping a trout stream on an off day. Should the faint tracing of a backbone or a fin appear, the protecting shale is scraped away carefully with a fine knife blade, exposing one of nature's "reliefs."

scattered at the bottom of the ancient ocean bed.

Among the strange ocean rulers were the armor-clad fish; then, in turn, the fierce, sharp-toothed sharks, the fish lizards, the mysterious ichthyosaurus, the plesiosaurus, whose names are only a little less terrifying than the havoc they spread among the fish lizards crawling in the mud of ocean bed.

The great marine reptiles called Mosasaurus, geologists believe, ruled the seas from New Zealand to North America at one time in the remote past. These ancient reptiles, at their most fearsome prime, meas-

ured from 25 to 40 feet in length.

The Rocky Mountains—so placid and gray now by daytime—swarmed with heroic battle in the days when they were still ocean bed. Huge turtles, saber-toothed divers, the monstrous fish of legend, all fought for supremacy, and over the waters flew the pterodactyls, dark, menacing shadows, with their powerful wingspread of 20 feet or more.

While the rival fish species spawned, fought, and died, the surface of the North American Continent was gradually taking form. The land which made up the ocean bed was rising with monumental slowness—an inch, perhaps an inch and a half, a century.

END OF THE NORTH AMERICAN OCEAN

At last the "ocean" on the North American Continent was completely enclosed on the west and on the east by elevations of sea bottom, so that it connected with the Atlantic and Pacific Oceans

as we now know them only at the Gulf of Mexico and the Arctic Circle. Continued elevations of the eastern and western edges contracted the area of this vast inland ocean, and parts of the ancient sea bottom rose, reached the surface, forming bars and vast fingers of land. Parts of the water area were contracted into inland lakes, until, at last, they lost all contact with salt water.

Thus the living creatures—the turtles, the great saber-toothed fish, the gar pike—were imprisoned in fresh-water lakes. The weaker tribes perished slowly, tribe by tribe, lost to their salt-water habitat. With the death of many of the smaller, weaker tribes

of fish, the main food supply of some of the larger and more ferocious sea creatures was diminished, and they, too, perished, hapless prisoners in their trap of earth.

Even though millions of creatures lived and died in the oceans which through the natural geologic change of time became mountains, lakes, and valleys, comparatively few fossils remain to tell the tale. In order to fossilize, objects must first be protected from the air completely. Nature accomplishes this only by burying them in wet ground.

The fossil fish must first have settled to the ocean or inland lake bed. He must have found quiet waters, after his life's struggles, where the wash of waves on the shores would gently wear away the sand or rock. This pulverized rock or sand must then have settled gently over the fish. His bones, little by little, must have been covered by a fine deposit which would embrace every fin and scale, fill every groove so gently as to preserve each delicate outline.

Every schoolboy fisherman, questing with a bent hook in the old mill-pond, has pulled out from the sucking mud some old shoe or tin bucket. The sea creatures of millions of years ago settled first into the mud much as the old boot does—and the first stages of their fossilization had begun.

NATURE "MOUNTS" A FOSSIL

The crust of the earth was rising and falling, just as it is today, and the layers of mud in which the fish were buried became increasingly thick. The lime, or silica, in the water cemented the particles of mud



Photograph by Imogene Powell

"FISHING" WITH CHISEL AND HAMMER

For 37 years Robert Lee Craig, as amateur sportsman extraordinary, has been angling patiently in the rocks at Fossil, Wyoming, to provide fossilized fish for museums and private collections. Here he cleaves a slab of shale, finding several valuable specimens (see text, page 355).

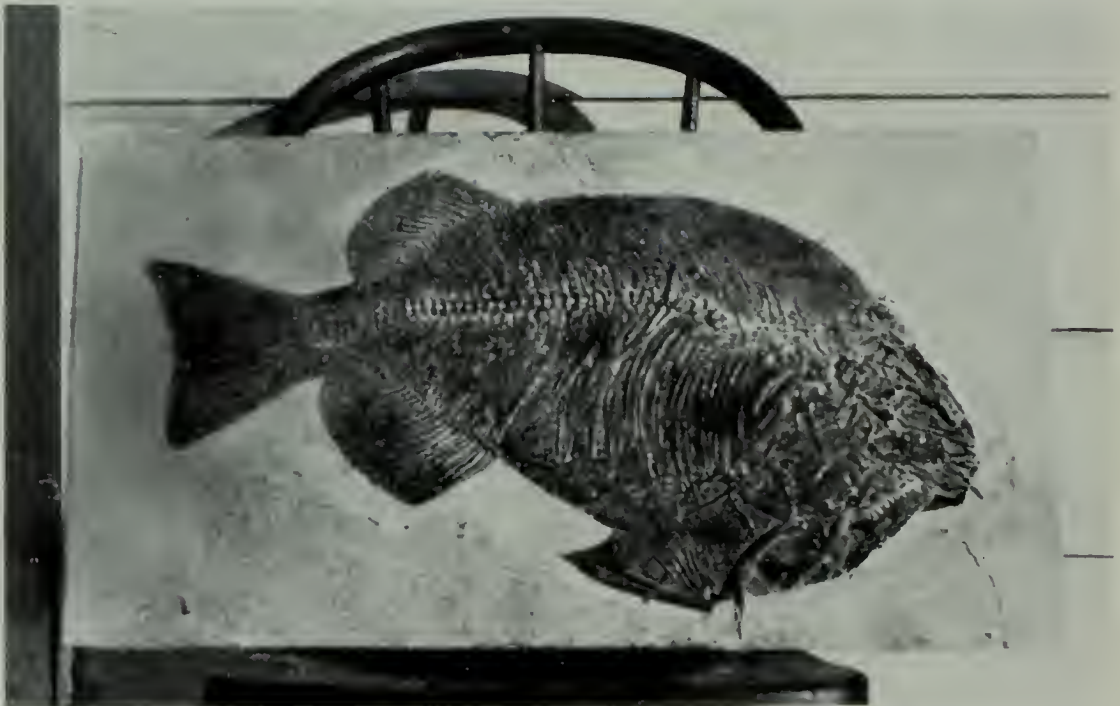
and the grains of sand into a solid mass, a process speeded by the constant slow pressure of the overlying sediment, the heat created by this pressure, and likewise the heat from the earth beneath.

During this process of slow burial, solidification of rock, and pressure from the earth below and above, the animal matter of the creatures embedded disappeared completely. The place of flesh and bone and fin was taken by the lime or silica deposit, and the hardened rock surrounding it formed the layers which millions of years later were to emerge as fossil rock, a perfect protection for the fish buried there. The chemical change which produced this meta-



ONE "CAST" HOOKS THREE BIG ONES

Not often does the splitting of a single slab of rock so abundantly reward the fossil hunter. Nature has mounted in stone a herring, a *Dapedoglossus*, and a basslike fish. Carbon in the bodies causes them to show up dark against lighter-colored shale.



Photographs by Imogene Powell

HIS COUSINS STILL SWIM IN THE RIVERS OF FOUR CONTINENTS

This unusually large *Dapedoglossus* is one of the finest "strikes" that Robert Lee Craig had while quarry fishing. Of the five living species of the family to which this extinct member belongs, one is found in Australia, another in the Malay Archipelago, a third in tropical Africa, and two in the Amazon—one being the pirarucú, the largest fresh-water fish in the world.

morphosis in a fish of flesh and scale is a fit subject for a fisherman's solitary speculation. The exact manner is unknown, even to the geologist, and the transmutations through which the ancient gar pike went before he emerged a perfect fossil specimen could have been achieved only by the patient alchemy of ages.

Worsted in some encounter with a stronger gar pike, he went to the bottom of the sea—a Mr. Hyde of corruptible flesh and fin. He emerges millions of centuries later—Dr. Jekyll, the image of himself in stone.

Even after mutable Time had caught him unaware, the gar pike, in fossilized form, had still only the remotest chance of coming anywhere near where the zealous fisherman could get at him. After he was transmuted to stone, Nature must still make the contents of the fossil rock accessible by turning the strata on edge.

This she did in her own peculiar fashion, by volcanic eruption, by heaving and buckling the fossil strata into cliffs and mountain edges, or by cleaving them into valleys and canyons.

Some fossil strata are lost forever to the prying human eye through too great an upheaval of Nature and the flattening out of other strata on top of them. Sometimes they are cracked by heroic movements of rock, and, if the fossil strata are cracked open and left to the mercies of sun and wind, snow and frost, these, their natural enemies, will quickly obliterate the fossil specimens.

ONLY ONE FISH IN MILLIONS EVER
BECOMES A FOSSIL

The chances a fish has to attain immortality as a fossil are one in a million. And that is why, when the fossil fisherman is in sight of a "catch," he feels very Eternity tugging at his line.

The sun sends long dun and purple shadows into the hollowed mine where you fish. You could not discern a fishbone, fin or backbone, in the gray rock even if you worked on. A cold and penetrating wind warns you that the day is done. There is the steep path for your tired feet—275 feet straight down, with dizzy depths of shale below you—then a long, winding, two-mile hike to town.

At the general store they ask you, "Any fish today?" You shake your head and hurry to the hotel, where supper is waiting and the white-haired lady, who has prepared

three hearty meals a day for 30 years against the coming of a crowd of sheep herders, does not even ask you about your luck.

Well—tomorrow, perhaps!

That is the way with fossil fishing. You go back tomorrow. R. Lee Craig has gone back each tomorrow for 37 years, despite the fact that he has just one leg and must climb the sheer mountain sides maintaining an uneven balance with a gnarled wood stick which serves him as a cane.

Fish that were raised from this same hill have gone to museums in all parts of the United States and in foreign lands. Geologists and paleontologists have visited Fossil and are counted among the personal friends of Mr. Craig. He has prepared what is considered the largest collection of fossil fish in the world for a Chicago collector.

HIS "TACKLE" IS PICKS, SHOVELS, AND
HAMMERS

Lee Craig has the ideal attributes of an angler. He is patient. He knows his wedges, picks, shovels, knives, hammers, and hack-saws as a sportsman knows his tackle. He handles them unfailingly, wedging into the soft rock with a sure touch, hammering here, cutting there, working with the soft and treacherous stone so as not to harm any specimens which may be hidden in those gray depths.

He has a certain indomitable spirit which has kept him fishing in those mountains all this time. He knows them so well that, walking up his trail and across the shifting edges of the fossil beds, where rock lies piled feet-thick, he can tell whether a stranger has passed that way. He knows by the rocks in the path, he says. "Tender-foot! Only a stranger would kick shale in his own path!"

Craig discovered his own particular fossil hill and his life's work on his way from Shoshone Falls, Idaho, to Laramie, Wyoming. He had some little previous experience digging fossils with his friend, Fred Brown, leader of expeditions which contributed dinosaurs to the Smithsonian collection. He had helped uncover the bones of that famous brontosaurus, that massive prehistoric creature which in life, it has been estimated, weighed as much as 20 horses. He saw what looked to be a field rich in fossils, and though he'd never seen the town of Fossil before, he promptly asked the conductor to unload him here. And here since that day he has stayed.

INDEX

COMPREHENSIVE BIOGRAPHIES AND SPECIES PORTRAYED IN THE COLOR PLATES ARE LISTED ALSO IN FRONT
PAGES OF THE BOOK OF FISHES

	A	Page
<i>Abudefduf saxatilis</i> (sergeant major)		160
Acclimatization		
Rainbow trout	121, 272	
Salmon	121, 285	
<i>Acipenser rubicundus</i> (lake sturgeon)		143
<i>sturio</i> (Atlantic sturgeon)		46
<i>transmontanus</i> (white sturgeon)	143, 281	
Acipenseridae (sturgeon family)	143, 281	
Adhesives. See <i>Habits and adaptations</i> .		
Adhesive organs	158, 213, 220	
<i>Actobatus nainari</i> (spotted whip ray)		166
Age of fishes		
Records of	100-101, 130, 141	
Told from otoliths	44, 101	
Told from scales	30, 101-102, 244, 285; ill.	97
Air bladders	20, 50, 235	
Airplane, Angler, fishing from	ill.	14
Airplanes, Dropping trout from to stock lakes		276
Alaska, Gulf of		223
Albacore	246; color plate	247
<i>Albatross</i> (ship)		239
Albemarle Sound; Marine life		300
<i>Albula vulpes</i> (bonefish)		201
Alewife	16, 31, 64, 338; color plate	65
Catch at Star-Mills, Middleboro, Massachusetts		ill. 49
Algae		26
Allison, James A.		171, 185
<i>Alosa sapidissima</i> (shad)		57, 244
Amberfish. See <i>Amberjack</i> .		
Amberjack	189, 192; ill. 186; color plate	205
See also <i>Runner and Yellowtail</i> .		
<i>Ambloplites ariommus</i> (southern rock bass)		115
<i>cavifrons</i> (rock bass)		115
<i>rupestris</i> (rock bass)		115
Ameiuridae (catfish family)		104
<i>Ameiurus melas</i> (black bullhead)		104
<i>nebulosus</i> (horned pout)		104, 106
American Museum of Natural History, New York City	25, 81, 297, 308, 315	
Amia	180-181	
Anadromous fish migration	12, 46, 57, 64, 70, 143, 264, 281, 285, 287, 289	
Anchovy		62
Northern	224; color plate	225
Andros Island, Bahama Islands	305, 308; ill.	304
Anemones		ill. 215
Sea	color plates 318, 322	
Sea chrysanthemums	color plate	319
White-armed	color plate	319
Angelfish		337
Black	ill. 302; color plate	154
Blue	147, 148; color plate	154
French	color plate	154
<i>Anglichthys isabellita</i> (blue angelfish)		154
Angler and fish	ill.	103
Angler fishes, Deep-sea		220
Angling. See <i>Game fishing</i> .		
<i>Anguilla</i> (fresh-water eels)		264
<i>bostoniensis</i> (fresh water eel)		145
<i>vulgaris</i> (European fresh-water eel)		145
"Animals of the Past" (book)		351
<i>Anisotremus virginicus</i> (pork fish)		153
Annelida; Parasites of lobsters		26
<i>Anoplarchus purpurascens</i> (crested blenny)		235
Antennules of crabs		261
<i>Aplocheilichthys grunniens</i> (fresh-water drum)		106
Aquiculture	98, 108, 110, 121, 128	
See also <i>Artificial propagation and Hatcheries</i> .		
<i>Archoplites interruptus</i> (Sacramento perch)		283
<i>Archosargus probatocephalus</i> (sheepshead)	66, 91	
Aristotle (philosopher)	75, 255	
Armor-clad fish		352
Artificial propagation	30, 95; ill.	61
Black basses		108
Salmon	30, 263	
Shad	30, 57	
Trout	121, 263, 272, 274	
Wall-eyed pike		134
Whitefish		117
See also <i>Aquiculture and Hatcheries</i> .		
<i>Ascaphus</i> (tailed frog)		267
Atlantic and Gulf of Mexico fisheries; Weights of catches for 1937		3

	Page
Atlantic City, New Jersey: Marlin and tuna fishing	39
Atlantic Highlands, New Jersey	25
"Aurora" (painting): Copied on helmet shell	ill. 297
Ausable River, New York	ill. 88
Australian lung fish	100
Average depth of sea	9
Ayers, (Dr.) W. O.	239
B	
Baird Station, California	285
Bait 100, 110, 115, 119, 128,	263
See also <i>Nets and gear</i> and <i>Tackle: Game fishing</i> .	
Baja California: Dead fish in desert	ill. 22
Baker's Beach, California: Surf fishing for striped bass	ill. 233
<i>Balistes vetula</i> (queen trigger-fish)	157
Barbels. See <i>Senses and sense organs: Barbels</i> .	
Barbour (naturalist)	34
Bargaining for helmet shells	ill. 298
<i>Barnaby Rudge</i> (novel)	292
Baracles on carapaces of market crab	259
Barracuda 151, 188, 217; ill. 178, 186; color plate	193
Muskellunge compared with	141
Bass	
Black 209; ill. 122, 136	
Black spotted	109
Calico. See <i>Crappie, Black</i> .	
Channel	ill. 10
Large-mouth black 101, 108; color plate	109
Rock 101, 115; color plate	114
Sea 39, 84; color plate	85
Small-mouth black 108, color plate	109
Southern rock	115
Spotted	108
Strawberry. See <i>Crappie, White</i> .	
Striped 38, 82, 101, 327; color plate	83
Surf fishing, Baker's Beach, California	ill. 233
White sea 244; color plate	245
Basses: Spawning habits.	103
Batchelder, A. G.	171
Beach lavender (plant)	308
Beaks of parrotfishes. 160; color plate	320
Bean, T. H.	239
Beau Gregoys	163
Belone (pipefish)	255
Belonidae (needlefish family)	226
"Bends" (condition experienced by divers)	235
Bering Sea	223
Berkeley, (Mr.)	230
Bermuda: Spawning ground of eels.	12, 145
Bible, Fishing mentioned in.	95
Bizelow, Henry Bryant	34
Billingsgate (market), London	13, 338
Biloxi Channel, Mississippi: Tarpon caught in	ill. 332
Bimini, Bahama Islands 36, 171, 175, 177,	328
Hauling giant ray ashore	ill. 172
Birds feed on fish	179, 219
Black Gnat (fishing fly)	272
Black spots characteristic of most trout	268, 269
Black will. See <i>Bass, Sea</i> .	
Blackfish. See <i>Bass, Sea</i> and <i>Tautog</i> .	
Alaskan	267
Blacksmith: Related to garibaldi	230
"Bleeding tooth" (snail)	307
Blenny	220
Crested	222, 235
Blessing fish: St. Dunstan's, London, England	ill. 13
Block Island, Rhode Island: Fisheries	58
Blue points (oysters)	347
Bluefish 31, 38, 86; color plate	87
Boats	
Fishing 246; ill. 22, 58, 59, 60, 61, 242, 252,	293, 340, 346
Rammed by swordfish 75; ill.	190
Type used for tuna fishing	246
"Bobbin" (method of catching lake trout through ice)	119
"Bobbing for eels"	145
Boca Grande, Florida	332
Bonefish 186-187, 202; color plate	201
Bonito 86, 339; color plate	87
Bonneville Dam, Columbia River: Fishways air view	265
	ill. 264
Boston, Massachusetts	11, 31
Fishing boats.	ill. 22, 59

	Page		Page
"Boston bluefish" (pollock)	338	Catfishes	283, 337
Boston scrod (young cod)	337	Climbing wall: Jumna River, India	ill. 213
Bothidae (flatfish family)	259	Commercial importance	104
Boulenger, G. A.	100	<i>Calostomus</i> (suckers)	270
Bowfin. See <i>Mudfish</i> .		<i>occidentalis</i> (Sacramento sucker)	279
Boy with dog: Fishing	ill. 113	Cavalla	224
Breder, (Dr.) Charles M., Jr.	103, 143, 327	Caviar	
Breeding habits	12, 14, 103, 220, 222, 235	Made from salmon eggs	281, 285, 338
Basses, 103; Catfishes, 104, 106; Cod, 40; Crested blenny and clingfish, 222; Cultus cod, 237; Eels, 145; Grunion and surf smelt, 220; Halibut, 44, 222; Lumpfish, 12, 14; Mackerel, 53; Minnows, 103; Muskellunge, 141; Pipefish, 255; Sacramento perch, 283; Salmon, 12, 70, 285, 287, 289, 291; Sea catfishes, 14; Stickleback, 12, 14; Sturgeon, 46, 281; Surf fishes, 228, 235, 241, 255; Tarpon, 334; Trout, 119, 121, 128-130, 270, 272, 274, 293; Tuna and albacore, 55, 246; Wall-eyed pike, 134; White perch, 130; Yellow perch, 132		Made from sturgeon roe	17, 46, 143, 281
Breton (cape), Nova Scotia: Tuna caught near	ill. 36	Substitutes	338
Brighton Aquarium	100	"Cays" (small islands)	303
British Columbia, Province of: Studies of pilchard	244	Census taker counting salmon: Bonneville Dam	ill. 264
British Museum, London, England	239	Centrarchidae (sunfish and bass family)	108, 110, 115, 267, 283
Broadbill	339	<i>Centropomus philadelphicus</i> (species of sea bass)	84
Brontosaurus (dinosaur)	355	<i>striatus</i> (sea bass)	84
Bronzeback. See <i>Boss, Black</i> .		Cephalic fins: Giant ray	166, 169; ill. 170
Brood pouches of male fishes	14, 149, 156, 254, 255	Cephalopods	169
Brooklyn Bridge, New York	ill. 344	<i>Cestus veneris</i> (Venus's-girdle)	299
<i>Brosme brosme</i> (cusk)	51	<i>Chaetodipterus faber</i> (spade fish)	147, 154
Brown, Fred	355	<i>Chaetodon capistratus</i> (four-eyed fish)	155
Bryozoa	26, 248; color plates 318, 321	<i>ocellatus</i> (butterfly fish)	147, 155
"Buckie". See <i>Whelk, Furbelowed</i> .		Chagres River, Panama: Tarpon fishing	327
Buckler plates: Sturgeons	143, 281; color plates 142, 280	Chapman, A. B.	143
Bullhead (catfish)		Charcoal burner's camp, Cuba	ill. 330
Black	104	Charrs	293
See also <i>Horned pout</i> .		Chelalis River, Washington: Washington mud minnow	267
Bullhead (sculpin). See <i>Sculpin, Marbled</i> .		Chelipeds of shrimp	255
"Bully" (iron hoop used in catching turtles)	192	<i>Chelonia mydas</i> (green turtle)	208
"Bullying" (method of catching turtles and lobsters)	192, 209	Cherry stone (clam)	347
<i>Bushnell</i> (ship)	226	Chesapeake Bay	38, 39, 300
Butler, George E.	134	Chesapeake Bay Biological Station, Maryland: Tagging fish	ill. 73
Butterfish	31, 68, 296, 337; ill. 300; color plate 69	"Chinook": Indian name for Pacific salmon	263
Butterfishes: Association with red-rayed jellyfish	296, 300	<i>Chiropsis decagrammus</i> (kelp greenling)	239
Butterfly fish	147; color plate 155	Chitons	307-308
		Chowder (clam)	347
		<i>Chromis punctipinnis</i> (blacksmith)	230
		Chub. See <i>Tautog</i> .	
		Saltwater. See <i>Tautog</i> .	
		Chummer (fishing boat)	218
		"Chumming": Albacore fishing	246
		Ciscoes	117
		<i>Citharichthys sordidus</i> (mottled sand dab)	259
		Clams	
		Hard	31
		Names indicate size	347
		Soft	31
		Claspers: Skates, rays and sharks	257
		Claws	
		American lobster	323
		Spiny lobster (West Indian)	204, 313
		Clingfishes	220, 222
		<i>Clupeo harengus</i> (herring)	64, 338
		<i>pollosii</i> (Pacific herring)	244
		Clupeidae (herring and shad family)	224, 244
		Coalfish. See <i>Pollock</i> .	40
		Cobb, (Dean) John N.	293
		Cod	31, 40; ill. 20, 63, 347; color plate 41
		Blue. See <i>Sculpin, Marbled</i> .	
		Cultus	237; color plate 236
		Green. See <i>Pollock</i> .	
		Ling. See <i>Cod, Cultus</i> .	
		Cod (cape), Massachusetts: Marine life	295, 299
		Cod, Image of: Statehouse, Boston, Massachusetts	ill. 11
		Cod-liver oil	63
		Codfishes	
		Commercial importance	40
		Historical importance	40
		Pollock destructive to young cod	40
		Substitutes	337, 338
		Coea (stomach appendages): Smelt	77
		<i>Cocnobito diogenes</i> (land hermit crabs)	308
		Coker (Dr.) Robert Ervin	106
		"Cold Wall," Atlantic Ocean	295
		Colgate University, Hamilton, New York	182
		Coloration of fishes	66, 79, 86, 102, 115, 128, 148, 149, 152, 165-166, 220, 228, 230, 235, 237, 239, 241
		Protective	21-22, 42, 150, 161, 164, 180, 236
		Variation with depth of water	152, 220
		Columbia River: Indians salmon fishing	ill. 277
		Comb jellies (ctenophores)	298-299
		Rosebud	color plate 311
		Venus's-girdle	color plate 311
		Commensalism. See <i>Parasitism and Commensalism</i> .	
		Conch divers	ill. 294
		"Conch pearls"	305
		"Conchs" (natives of Bahama Islands)	307; ill. 305
		Conchs (shells)	171; ill. 215, 343
		Cameo helmet shell	305-306; ill. 297, 307; color plate 312
		Queen	297, 303, 305; color plate 312
		West Indian	180
		Connecticut state lobster hatchery, Noank, Connecticut	ill. 73

	Page		Page
Conservation		Dab	347
Artificial propagation	30, 57	Dace	267, 270
Transplantation	96	<i>Dactyloctenium quinquedentatum</i> (red-rayed jellyfish)	296, 297
Species: Atlantic salmon, 70; Halibut, 44, 222, 223		<i>Dapedoglossus</i> (fossil fish)	354, ill. 354
Lobsters, 30-31; Salmon, 264, 267; Shad, 57, 58		Davidson, (Dr.) F. A.	285
Shrimp, 230; Trout, 261, 268		Dead fish: Baja California	ill. 221
Continental shelf: Width influences marine life	300	"Deep-sea bluefish" (pollack)	338
Cooper, (Dr.) J. G.	239	Deep-sea fish fauna: Pacific Ocean	219
Corals	ill. 301, 302	Delaware Bay: Marine life	300
Cup	ill. 299	Delaware River, New Jersey: Sturgeon formerly abundant	17, 338
Coregonidae (whitefish family)	117	Demoiselle family	230, 231
<i>Coregonus</i> (lake whitefishes)	117	Desmarest (naturalist)	100
<i>Lepidion</i> (whitefish)	117	Devilfish. See Ray, Giant	
Cormorants used by Japanese fisherman	95	"Devil's Churn," Oregon: Surf fishing	ill. 232
Coronado. See Kummer		Diatoms	91
Coronado Islands, Mexico. Fishing grounds	243	Digby, Nova Scotia: Fish drying	ill. 16
Corsairs. See Rockfish, Red		Dimock, Anthony W.	328
<i>Coryphaena hippurus</i> (dolphin)	200	Dimock, Julian	328
Cottidae (sculpin family)	241	Dipnet, Catching salmon with: Columbia River	ill. 277
<i>Cottus</i> (sculpins)	270, 279	Diver feeding specimens: Marineland Aquarium, Florida	ill. 166, 167
Counting salmon, Census taker: Bonneville Dam	ill. 264	"Diving conchs": Bahama Islands	305
Covered wagon: Fossil, Wyoming	349; ill. 351	Diving for sponges	325
Cow pilot. See Surge wrangler		Dog whelk	299
Cowry, Spotted	306-307; ill. 299; color plate 314	Dogfish	55
Crab		Dollarfish. See Butterfish	
Ghost	303; color plate 309	Dolphin	186; ill. 186; color plate 200
Green	color plate 317	Double gauge for lobster traps	30, 31
Hermit	ill. 215	<i>Dromidia antillensis</i> (sponge crab)	325
Japanese	209	Dropping fish from airplanes to stock lakes	263
Jonah	color plate 317	Drum	
Kelp. See Crab, Sheep		Fresh-water	106; color plate 107
Land hermit	308; color plate 315	Red	ill. 89
Mangrove	307; color plate 314	Sea	107
Market	259; color plate 258	"Drummer." See Squeteague, Gray	
Mountain	color plate 315	Dye made from black mussels	318
Mud	307; color plate 314	Dynamite explosions in water kill fish	219
Red mountain	308		
Rock	235; color plate 234		
Sheep	250; color plate 251		
Soft	31		
Spider	250; ill. 299		
Fossilized	250		
Sponge	325; color plate 316		
Tropical rock	308		
White land	308; color plate 315		
<i>Crago nigricauda</i> (black-tailed shrimp)	255		
Cragonidae (crustacean family)	255		
Craig, Robert Lee	349, 350, 354, 355		
Photograph of	ill. 353		
Crampfish. See Ray, Electric			
Crappie			
Black	101, 110; ill. 125; color plate 111		
Pale. See Crappie, White			
Ringed. See Crappie, White			
White	110; color plate 111		
Crappies	337		
Crater Lake, Oregon	ill. 126		
Crawfish, Ghost shrimp are called	238		
Fresh-water. See also Crayfish, Fresh-water			
"Crawls" (enclosures for sponges)	325		
Crayfish	100; ill. 341		
Fresh-water	209		
West Indian. See Lobster, Spiny			
Crevalle family	151		
<i>Cristivomer namaycush</i> (lake trout)	119		
Croaker	31		
Crown melongena (whelk)	306		
Crownshield, B. W.	332		
Ctenophores (comb jellies)	298-299		
Cuba			
Spearing viajaca	ill. 329		
Tarpon found in	327, 328, 332, 334, 336; ill. 326, 330, 331, 335		
Cuboid medusa	298; color plate 311		
Cuckold	150; color plate 157		
"Cultus" (Chinook for worthless)	236		
Cunner	color plate 322		
Currents			
Influence on marine life	295, 296, 299		
See also Gulf Stream: Influence on marine life			
Cusk	31, 51, 338; color plate 50		
Customhouse tower, Boston, Massachusetts	ill. 22		
Cutten, (Prof.) George Barton	182		
<i>Cynoscion nebulosus</i> (spotted squeteague)	82		
<i>nobilis</i> (white sea bass)	244		
<i>nothus</i> (bastard trout)	82		
<i>regalis</i> (gray squeteague)	82		
<i>Cypraca exanthema</i> (spotted cowry)	306		
Cyprinidae (minnows and carps)	279		
Cyprinids	267, 270, 279		
<i>Cypselurus californicus</i> (California flying fish)	266		
		D	
		Dab	347
		Dace	267, 270
		<i>Dactyloctenium quinquedentatum</i> (red-rayed jellyfish)	296, 297
		<i>Dapedoglossus</i> (fossil fish)	354, ill. 354
		Davidson, (Dr.) F. A.	285
		Dead fish: Baja California	ill. 221
		"Deep-sea bluefish" (pollack)	338
		Deep-sea fish fauna: Pacific Ocean	219
		Delaware Bay: Marine life	300
		Delaware River, New Jersey: Sturgeon formerly abundant	17, 338
		Demoiselle family	230, 231
		Desmarest (naturalist)	100
		Devilfish. See Ray, Giant	
		"Devil's Churn," Oregon: Surf fishing	ill. 232
		Diatoms	91
		Digby, Nova Scotia: Fish drying	ill. 16
		Dimock, Anthony W.	328
		Dimock, Julian	328
		Dipnet, Catching salmon with: Columbia River	ill. 277
		Diver feeding specimens: Marineland Aquarium, Florida	ill. 166, 167
		"Diving conchs": Bahama Islands	305
		Diving for sponges	325
		Dog whelk	299
		Dogfish	55
		Dollarfish. See Butterfish	
		Dolphin	186; ill. 186; color plate 200
		Double gauge for lobster traps	30, 31
		<i>Dromidia antillensis</i> (sponge crab)	325
		Dropping fish from airplanes to stock lakes	263
		Drum	
		Fresh-water	106; color plate 107
		Red	ill. 89
		Sea	107
		"Drummer." See Squeteague, Gray	
		Dye made from black mussels	318
		Dynamite explosions in water kill fish	219
		E	
		Eagle-rays	166
		"Ear bones." See Senses and sense organs: Otoliths	
		Ears of fishes. See Senses and sense organs: Hearing	
		Eastport, Maine: Unloading fish	ill. 35
		<i>Echeneis naucrates</i> (shark sucker)	158
		Ecology of fishes	103
		Eel	
		Common	337
		Conger	15, 337
		Deep-sea	337
		Electric	250
		European freshwater	12, 100, 145
		Freshwater	12, 145; color plate 144
		Green moray	151; color plate 155
		Moray	147; ill. 146
		Eel grass	color plate 320
		Eels	12, 100, 264, 145; ill. 15
		Egg-bearing lobsters illegal for capture	30, 81, 323
		Egg cases	
		Dog whelks	color plate 318
		Skates	257
		Eigenmann, C. H.	34
		Electric glands: Electric ray	250
		Elk Grove Hatchery, California	283
		Elliott Bay, Seattle, Washington: Angler and salmon	ill. 253
		Flvers (young eels)	12, 145
		<i>Embiotoca jacksoni</i> (black perch)	255
		Embiotocidae (surf fishes)	228, 241, 255
		Endemic species: United States	96, 267
		Enderbury Island, Pacific Ocean	248, 250, 255
		Enemies of fishes	15
		Engraulidae (anchovy family)	224
		<i>Engraulis mordax</i> (northern anchovy)	224
		Entomostraca (subclass of crustaceans)	100
		Eocene deposits, Green River shales, Wyoming	267
		<i>Épée de mer</i> (swordfish)	74
		<i>Epinephelus adscensionis</i> (rock hind)	158
		<i>morio</i> (red grouper)	195
		<i>striatus</i> (Nassau grouper)	195
		Equilibration, Ears of fishes are organs of	19
		<i>Eretmochelys imbricata</i> (shell turtle)	208
		Eschmeyer, (Dr.) R. W.	132
		Esocidae (pike family)	139, 141
		<i>Esox americanus</i> (banded pickerel)	139
		<i>lucius</i> (American pike)	139
		<i>masquinongy</i> (muskellunge)	141
		<i>niger</i> (eastern pickerel)	139
		<i>Espada</i> (swordfish)	74
		Eulachon	77, 281; color plate 280
		<i>Euspongia</i> (genus of commercial sponges)	325
		<i>offinalis</i> (sponge)	325
		Evermann, (Dr.) Barton Warren	34, 239

	Page		Page
Glass floats used by Japanese fishermen	224	Herring hog (porpoise)	173; ill. 170
Glochidia (larval stage of mussel)	106	Herringlike fossil fishes found in Green River shale	244
Gloucester, Massachusetts: Codfish	ill. 20	Wisconsin	249
Glue, Air bladders used in manufacture of	50	Hexagrammidae (greenling family)	34, 68
Goutfishes, Yellow	ill. 301	Hildebrand, (Dr.) Samuel P.	148, 149, ill. 146; color plate 158
"Goggle eye" See Bass, Rock		Rock	149, ill. 146
"Goin' Fishin'" (photograph)	ill. 94	Spotted rock	ill. 146
Golden Gate Park, California: Surf fishing near	233	<i>Hippocampus</i> (sea horse)	156
Goldfish sold as "sand perch"	339, 347	<i>Hippoglossus hippoglossus</i> (halibut)	44
<i>Goniopsis orientata</i> (man-of-war crab)	307	<i>Hippopongia</i> (genus of commercial sponges)	325
Gooder, (Prof.) G. Brown	34, 86	Hogfish	ill. 164
Gorgonians	ill. 183, 302; color plates 312, 316	Spanish	66
Gowanlock, (Mr.)	110	<i>Holocanthus tricolor</i> (rock beauty)	15
<i>Grampus</i> (ship)	79	Holder, Charles F.	5
Grand Banks, Atlantic Ocean	59	<i>Holo centrurus ascensionis</i> (squirrel fish)	153
<i>Grapsus grapsus</i> (tropical rock crab)	308	Holothurians	181; ill. 305
Gray Hackle (fishing fly)	272	<i>Homarus americanus</i> (American lobster)	81, 209, 323
Great Bahama Bank	308	<i>vulgaris</i> (European lobster)	81
Great sea star	color plate 312	"Homing instinct" of fishes	12, 264
Greeley, (Dr.) John R.	103	Hooked jaws developed in spawning salmon	70, 291; color plates 286, 288, 325; ill. 294
Green River shales, Wyoming: Fossil fish	244, 283	"Hooking sponges"	95
Greenfish. See Opaleye.		Hooks, Bent wood, used by Aleuts	104, 106; color plate 105
Greenling, Kelp	239; color plate 238	Horned pout	ill. 48
"Grilse" (immature Atlantic salmon)	70	Horse mackerel. See Tuna.	98, 99
Grosvenor, Gilbert: Photographs by	ill. 36, 217	Hosts, Fishes act as for mussels	108, 134, 219, 226, 268
Grouper		Hubbs, (Dr.) Carl L.	39
Black	188; color plate 196	Hudson River	219
Nassau	188; color plate 195	Hull, England	31
Red	188; color plate 195	Hull-Grimby, England	248, 250, 255
Groupers	180, 185-189, 337; ill. 186	Hull Island, Pacific Ocean	108
"Grumpy" (turtle): Marineland, Florida	ill. 167	<i>Hura saumoides</i> (large-mouth black bass)	285
Grunion	220	Hutchinson, S. J.	15
Grunt		Huxley (naturalist)	316
Common	165, 166	Hydroid coral	248; color plates 317, 318, 321, 322
French	166	Hydroids	230
Yellow	165; ill. 301; color plate 159	<i>Hypsops rubicundus</i> (garibaldi)	
Grunt family	189, 198		
Grunts	165; ill. 146	I	
Gudger, (Dr.) Eugene Willis	34, 261	Ichthyosaurus (extinct marine reptile)	352
Gulf Stream: Influence on marine life	79, 147, 169, 295, 296, 299, 300, 327	<i>Ictalurus furcatus</i> (blue catfish)	104
Gunfire does not cause disappearance of fish	219	<i>punctatus</i> (channel catfish)	104
Gurnards (fish): Ability to fly	226	Illinois River, Paddlefish caught in	ill. 137
<i>Gymnothorax funebris</i> (green moray)	155	"In berry" (female lobster bearing eggs)	30, 81, 209, 323, ill. 19; color plate 204
		Indian River Inlet, Florida	37
II		Indian spearing fish	ill. 112
Iabakkuk (prophet)	95	Indians fishing for salmon: Columbia River	ill. 277
Habits and adaptations of fishes	102-103	Insects, Fish feed on	100
Haddock	31, 40, 337, 338; color plate 41	International Fisheries Commission, United States-	Canada 44, 223, 239
Offshore	28	International tuna tournament: Nova Scotia	36
Shore	38	Irish moss	color plate 317
<i>Haemulon album</i> (margate fish)	198	Ironsides. See Scup.	51
<i>sciurus</i> (yellow grunt)	159	Isinglass, Air bladders used in manufacture of	203
Hake	31, 347	<i>Istiophorus americanus</i> (Atlantic sailfish)	
Silver. See Whiting.		J	
Squirrel	51; color plate 50	Jack. See Pickerel, Eastern.	180; ill. 146
White	51	Jacks (amberjacks)	254
Halibreaks: Related to California flying fish	226	Jackson, (Dr.) A. C.	223
Halibut	44, 337; ill. 59; color plate 45	Japan Current, Pacific Ocean	276
Pacific	222, 339	Jasper Park, Alberta, Canada: Anglers	317
<i>Halocypridus</i> (genus of flying fish)	226	Jelly made from Irish moss	color plate 322
"Hard shells" (crabs)	317	Jellyfishes	298; color plate 311
Hardhead, Biologist tagging	ill. 73	Cuboid medusae	297; color plate 311
Harpooning fish	75, 173, 175	Mushroom	color plate 311
Harpooning spiny lobsters	209	Pelagia	296-297
Hart, (Dr.) J. L.	117	Purple oceanic	296
Harvest fish	68	Red-rayed	186
See also Butterfish.		Jewish	188; ill. 151, 167, 196
Hatcheries	108, 117, 134, 141, 274, 276	Jicarón Island, Gulf of Panama: Tuna fishing	ill. 218
Rainbow trout, Warren, New Hampshire	ill. 127	Johnson (cape), Washington	220
See also Aquiculture and Artificial propagation.		Jones, William S.	37
Hatteras (cape): Marine life	300, 327	Jordan, (Dr.) David Starr	34, 239
Hawksbill. See Turtle, Shell.		Jumna Canals, India	213
Hazard, (Dr.) Albert S.	103, 128	Jumna River, India: Catfishes climbing from	ill. 213
Headfishes: Group to which ocean sunfish belong	261	Jumper. See Mullet.	91
Hearing, Sense of. See Senses and sense organs: Hearing.			
Helmet shell. See Conchs: Camco helmet shell.		K	
Hemiramphidae (halfbeak family).	226	Kamchatka Peninsula, Siberia	223
Hermaphrodite, Some fishes are	180	Kelp, Fronds of.	color plate 319
Herrick, (Dr.) Francis H.	25, 81	Kennebec River, Maine	339
Suggestions for conservation of lobster fisheries	30-31	Kern River, South Fork of: California	268, 269
Herring	31, 64; ill. 18, 62; color plate 65	Key West, Florida, Spanish mackerel shipped from	189
Commercial importance, 64, 338; Fossilized, ill. 350, 354; Food value, 60; Tagging, 222-223		"King of the herring"	219
Big-eyed. See Alewife.		Kingfish (croaker family). See Whiting, King	
Branch. See Alewife.		Kingfish (mackerel family)	189; ill. 186; color plate 190
Glut	16, 64		
Lake	337		
Pacific	244		
Rock. See Ciscos.			
Wall-eyed. See Alewife.			
Herring family	62, 327		

	Page
Muskellunge 101, 139, 141 ill 124 color plate 140	
"Muskie" (muskellunge) 140; ill 121	
Musquellunge See Muskellunge	
Mussel	
Black color plate 318	
Butterfly 106	
Horse color plates 318, 322	
Pearl 98-99, 106, 107	
Sea 33	
Washboard 106	
Mussels, Propagation of Mississippi Valley 98	
Mutilations overcome in fish 68	
Muttonfish 189, 195, 337; ill 184; color plate 194	
<i>Myxopoma bonaci</i> (black grouper) 196	
<i>microlepis</i> (gag) 196	
N	
Namaycush. See Trout, Lake	
Nassau, Bahama Islands: Sponge market ill. 304	
Natural foods for game fishing 263	
Navesink (river), New Jersey 327	
Needham, (Dr.) Paul R. 272	
Needlefishes: Related to California flying fish 226	
<i>Nerita</i> (genus of snails)	
<i>peloronta</i> (snail—"bleeding tooth") 307	
<i>tesellata</i> (snail) 307	
<i>versicolor</i> (snail) 307	
Nests of fishes 104, 106, 108, 110, 115, 128, 222, 235, 267, 270, 272, 274, 279, 287, 289	
Three-spined stickleback color plate 275	
Nets and gear 30, 31, 40, 42, 44, 53, 55, 57, 64, 68, 75, 77, 82, 84, 93, 95, 117, 119, 130, 145, 222, 223, 224, 230, 237, 244, 246, 248, 255, 257, 285, 287, 289, 291, 293; ill. 24, 48, 49, 58, 60	
Nettle cells: Portuguese man-of-war 296; color plate 310	
New Brunswick 60	
New England: Largest Atlantic fisheries 11	
New York Aquarium 101, 102, 128, 134, 250	
Whitefish ill. 137	
New York World's Fair: Eel drained from grounds ill. 15	
New York Zoological Society Bulletin 151	
Newport, Rhode Island: Fisheries 58	
Nichols, John T. 34	
Nipigon river, Canada, Fish caught in ill. 102	
Noank, Connecticut: Lobster hatchery 73	
Noises made by fishes 106	
<i>Nomus</i> (Portuguese man-of-war fish) 161	
<i>gronovii</i> (Portuguese man-of-war fish) 296	
North Bimini, Bahama Islands 171	
Northern Pacific Halibut Treaty, United States-Canada 222	
Northern shore fauna: Atlantic Coast 299	
Nova Scotia 62, 72, 299	
International tuna tournament 36	
<i>Novumbra</i> (Washington mud minnow) 267	
O	
Ocean City, Maryland: Tuna and marlin fishing 21, 39, 207	
Ocean goldfish. See Garibaldi	
Octopus 169, 171, 337; ill. 149; color plate 206	
<i>Octopus americanus</i> (octopus) 206	
<i>punctatus</i> (giant octopus) 169	
<i>Ocyropsis albicaus</i> (ghost crab) 303	
<i>Ocyropsis chrysurus</i> (yellow tail) 159	
Ojibway Indians fish with spears 112	
"Old man's beard" (seaweed) 308	
Old Spanish Trail boulevard, Mississippi 332	
<i>Oncorhynchus</i> (genus of salmon)	
<i>gorbuscha</i> (pink salmon) 289	
<i>keta</i> (chum salmon) 291	
<i>kisutch</i> (silver salmon) 285	
<i>nerka</i> (red salmon) 287	
<i>tschawytscha</i> (chinook salmon) 285	
Ontario (lake), Bronzeback caught in ill. 136	
Opah 261, 267; color plate 260	
Opaleye 248; color plate 249	
Operculum: Pilchard and Pacific herring 244	
<i>Ophiodon elongatus</i> (cultus cod) 237	
Ophiodontidae (cultus cods) 237	
Oppian: Quoted on swordfishes 75	
Optic nerves of flatfishes 11	
<i>Oreaster reticulatus</i> (great sea star) 303	
Orie, Golden 100	
Oscula of sponges 308, 324	
Osmeridae (smelt family) 281	
<i>Osmerus mordax</i> (smelt) 76, 77	
<i>Ostrea frons</i> (coon oyster) 306	
Otoliths (earbones of fishes) 44, 106	
Otter trawls used to catch cod 40	

	Page
Ova of fishes	
Number 14, 40, 42, 46, 51, 53, 57, 61, 75, 117, 138, 235, 237	
Size 40, 42, 43, 46, 51, 53, 64, 68, 75, 177, 20, 82, 91, 93	
Ovary uterus of surfishes 278, 241, 255	
Overfishing, Results of 28, 29, 30, 57, 64	
Ovipositor of female rock bass 115	
Ovoviviparous, Electric rays 250	
Oxygen dissolved in water, Fishes breathe 19, 20	
Oyster	
Blue point 347	
Coon 306, ill. 299; color plate 314	
Japanese 239	
Virginia 306	
Oyster fish. See Tautog	
Oysters	
Increasing scarcity 29	
Names indicate where grown 347	
Weight of catch for 1937 31	

P

<i>Pachychalium rubens</i> (red branched sponge) 308	
Pacific Biological Station, Nanaimo, British Columbia 239	
Pacific Coast fisheries: Value 219	
Pacific cultus. See Cod, Cultus	
Paddle-fish 143, 281, 338; ill. 137	
Pallas, Peter Simon (naturalist) 239	
Palinuridae (spiny lobster family) 248	
Pamlico Sound: Marine life 300	
Pampano (pompano) 224	
Pandalidae (crustacean family) 230	
<i>Pandalus platyceros</i> (prawn) 230	
<i>Parapopus herbstii</i> (mud crab) 307	
Panuco River, Mexico 332	
<i>Paralichthys argus</i> (spiny lobster) 204, 209, 306	
<i>interruptus</i> (spiny lobster) 248	
<i>penicillatus</i> (spiny lobster) 248	
<i>Paralichthys dentatus</i> (summer flounder) 42	
Parasitism and commensalism 98, 99, 106, 158, 161, 180-181, 260, 296, 300	
Parker, George Howard 34	
Paris, Treaty of 29	
Paris, France: Center for cameo cutting 306	
"Parr" (young Atlantic salmon) 70	
Parr marks: Trout 268, 269	
<i>Parribacus</i> (shovelnose lobster) 250	
Parrotfish 147	
Green color plate 160	
Parrotfishes 160	
Passaic River 38	
Pass Christian, Mississippi: Tarpon fishing 332	
Pearl buttons manufactured from Mississippi Valley mussels 98-99	
Pearse, (Dr.) A. S. 132	
Peavoy, Robert 141	
Pectoral fins, Unusual length of: Albacore 246	
<i>Pelagia</i> (jellyfish) color plate 311	
<i>Pelagia cyanella</i> (purple oceanic jellyfish) 297	
Pelicans 179	
Penobscot River, Maine 339	
<i>Pepelus alpeidotus</i> (harvestfish) 68	
Per capita yearly consumption of fish: United States 48	
<i>Perca flavescens</i> (yellow perch) 132	
<i>flaviventris</i> (European yellow perch) 132	
Perch	
Black 255; color plate 254	
Blue 228, 255; color plate 229	
European yellow 132	
Raccoon. See Perch, Yellow	
Red. See Perch, Yellow	
Ringed. See Perch, Yellow	
Rubberlip 241; color plate 240	
Sacramento 283; color plate 282	
Fossil remains 283	
Striped. See Perch, Blue, and Perch, Yellow	
Viviparous. See Perch, Blue	
White 130; color plate 131	
Yellow 101, 132, 337; color plate 133	
Perch cycle described by Eschmeyer 132	
Perch family 135	
Percidae (perch family) 132	
Peritoneum: Pilchard and Pacific herring 244	
Periwinkle 299	
Lesser color plate 318	
Zigzag 307	
Peto. See Wahoo	
Pharyngeal teeth of fishes 66, 106, 235, 279	
<i>Physalia arctusa</i> (Portuguese man-of-war) 156	
Pickarel. See Pike, Auckraa	
Banded 139	
Chain. See Pickarel, Eastern	
Eastern 139; color plate 138	

- | | Page | | R | Page |
|---|-------------------------------------|--|-------------------------------------|------|
| Pike | 337; ill. 98, 101 | Raccoons eat coon oysters | | 306 |
| American | 139; color plate 138 | Raritan River | | 38 |
| Blue | 134 | Rate of growth in fishes | 46, 51, 53, 57, 64, 68, 77, 82, 91, | 93 |
| Northern | 351 | Ray | | |
| Sacramento | 267, 279; color plate 278 | Electric | 250; color plate 251 | |
| Sand | 134; color plate 135 | Giant | 166, 175-177; ill. 168, 170, 172 | |
| Wall-eyed | 134; color plate 135 | Spotted whip | 166; ill. 150 | |
| Pike-perch, Yellow. See <i>Pike, Wall-eyed</i> . | | Rays | | |
| Pilchard | 62 | "Red eye". See <i>Bass, Rock</i> . | | |
| See also <i>Sardine, California</i> . | | "Red perch" (redfish) | 347 | |
| Pilot-fish | 163 | Red streaks on jaw of cutthroat trout | 268; color plate 271 | |
| Pinfish | 68 | Redfish | 347 | |
| Pink coralline | color plate 318 | Redfish (landlocked red salmon) | 287, 289 | |
| Pipe. Clay, used by hermit crab for shell | 308; color plate 315 | Redd (fish nest) | 108, 287 | |
| Pipefish | 250, 255; color plate 254 | Reef fishes | 148 | |
| Related to sea horses and sticklebacks | 255 | Regeneration of claws: Lobsters | 27 | |
| Reproduction | 255 | Reighard, (Dr.) Jacob | 103 | |
| Pirarucu | 354 | Remora | 163 | |
| Placoid scales on sharkskin | 257 | Reni, Guido | 297 | |
| Plankton: Importance as fish food | 30 | Reproduction, Modes of | 14 | |
| <i>Platichthys stellatus</i> (starry flounder) | 259 | Catfishes | 104, 106 | |
| <i>Plesiosaurus</i> (extinct marine reptile) | 352 | Pipefishes | 255 | |
| <i>Pleurobrachia pileus</i> (ctenophore) | 298-299 | Sharks and skates | 161, 163, 257 | |
| Pleuronectidae (flatfish family) | 259 | Surf fishes | 228, 235, 241, 255 | |
| <i>Pneumatophorus diego</i> (Pacific mackerel) | 224 | Reproductive polyps: Portuguese man-of-war | 296; color plate 310 | |
| Poison glands: Catfish | 104 | Respiration of fishes | 19-20 | |
| Poisoning from eating tropical fishes | 151 | <i>Rhacochilus toxotes</i> (rubberlip perch) | 241 | |
| Poisonous, Sculpin roe is | 241 | <i>Rhinichthys</i> (dace) | 270 | |
| Poisonous plant, Juice of used to stupify fishes: Tonga Islands | 95 | Richardson, (Sir) John | 239 | |
| <i>Pollachius virens</i> (pollock) | 40 | Richardson, Robert Earl | 132, 134 | |
| Pollock | 31, 33, 40, 63, 338; color plate 41 | Ricker, W. E. | 279 | |
| Pollock roe substituted for shad roe | 338 | "Rings" on salmon scale | ill. 97 | |
| Pollution of lakes and streams | 28, 30, 57, 64, 97 | Rio Encantado, Cuba: Tarpon caught in | ill. 331 | |
| <i>Polyodon spathulo</i> (paddle-fish) | 281 | Rio Grande Delta, Texas: "Fishing rodeo" | 151 | |
| Polyps, Coöperative: Portuguese man-of-war | 310 | Roanoke River | 38 | |
| <i>Pomacanthus arcuatus</i> (black angelfish) | 154 | <i>Roccus saxatilis</i> (striped bass) | 82, 130, 327 | |
| <i>paru</i> (French angelfish) | 154 | Rock barnacles | color plate 318 | |
| Pomacentridae (demoiselle family) | 230 | Rock beauty | 148; color plate 154 | |
| <i>Pomatomus saltatrix</i> (bluefish) | 86 | Rock snails (fish) | 220 | |
| <i>Pomolobus aestivalis</i> (glut herring) | 64 | Rock strata: Fossil, Wyoming | ill. 348, 352, 353 | |
| <i>pseudoharengus</i> (alewife) | 64 | Rockfish | | |
| <i>Pomoxis annularis</i> (white crappie) | 110 | Black | 228; color plate 229 | |
| <i>sporoides</i> (black crappie) | 110 | Red | 235; color plate 234 | |
| Pompano | 86, 187 | See also <i>Bass, Striped</i> . | | |
| Fish substituted for | 337 | Rockpilot family | 231 | |
| See also <i>Pampono</i> . | | Rockweed | color plate 318 | |
| Pompon weed | color plate 318 | Knotted | color plate 318 | |
| Porcupinefish | 150; ill. 164 | Rocky Mountains: Fossil remains | 351, 352 | |
| Ponce, Puerto Rico | 296 | Roe of fishes: Protein content | 60 | |
| Porgies, Southern | 68 | Rogue River, Oregon: Trout fishing | ill. 262 | |
| Porgy. See <i>Scup</i> . | | Rome, Italy: Center for cameo cutting | 306 | |
| Black. See <i>Tautog</i> . | | Rosebud (comb jelly) | color plate 311 | |
| Porgy family | 68, 90, 91 | Rosefish | 31 | |
| Pork fish | 148; ill. 146; color plate 153 | Roundheads. See <i>Kingfish</i> . | | |
| <i>Poronatus triacanthus</i> (butterfish) | 68, 69 | Rowe, John | 11 | |
| <i>Porpito</i> (floating colony) | 296 | Royal Coachman (fishing fly) | 272 | |
| Porpoises | 173; ill. 167 | Rudder fish family | 249 | |
| School of | ill. 184 | Runner | 192, 337; color plate 205 | |
| Portuguese man-of-war | 161, 295-296; color plates 156, 310 | | | |
| Portuguese man-of-war fish | 161, 296; color plate 310 | | | |
| Potomac River | 38, 39, 339, 347 | | | |
| Powell, Imogene: Photograph of | ill. 348 | | | |
| Prawn | 230; color plate 231 | | | |
| Precooling of fish | 33 | | | |
| Prehensile tail: Sea horse | 156 | | | |
| Pressure at ocean depths | 9 | | | |
| Primitive methods of fishing | 95 | | | |
| <i>Priscocoro pcalci</i> (fossil fish) | 349 | | | |
| <i>Protopium</i> (round whitefishes) | 117 | | | |
| <i>williamsoni</i> (whitefish) | 132, 270 | | | |
| Protein in fish meat | 60 | | | |
| Protozoa, Swallow-tail | color plate 321 | | | |
| <i>Pseudopleuronectes americanus</i> (winter flounder) | 42 | | | |
| <i>Pseudocarrus guacamola</i> (green parrotfish) | 160 | | | |
| Pterodactyls (extinct flying reptiles) | 352 | | | |
| <i>Ptychocheilus</i> (squawfish) | 270 | | | |
| <i>grondis</i> (Sacramento pike) | 279 | | | |
| <i>orgonensis</i> (squawfish) | 279 | | | |
| Puffer. See <i>Swellfish</i> . | | | | |
| Puget Sound Banks: Purse seine | ill. 252 | | | |
| Pumpkinseed. See <i>Butterfish</i> . | | | | |
| Purse seine: Puget Sound Banks | ill. 252 | | | |
| Purslane | 192 | | | |
| "Pusley" (purslane) | 192 | | | |

Q

- Quahaug (clam) 347
 Queenfish. See *Wahoo*.
 Quinte, Bay of, Ontario, Canada 117

S

- Sabalo*. See *Tarpon*.
 Saber-toothed fish 352
 Sable (cape), Florida 328
 Sable Island, Nova Scotia: Halibut fisheries 59
 Sac-a-lait. See *Crappie, White*.
 "Sail" of Portuguese man-of-war 296, 310; color plates 156, 310
 Sailfish 180, 182; ill. 216
 Atlantic 203
 St. Croix River, Wisconsin: Fisherman 124
 St. Dunstan's (church), London, England: Blessing fish 13
 St. John's, Newfoundland 23
 St. Pierre (island) 29
 "Sally Lightfoot" (tropical rock crabs) 308
Salmo (trout) 264
agua-bonita (South Fork golden trout) 268
clarkii (coastal cutthroat trout) 270
gairdnerii (rainbow trout) 121, 272
gairdnerii gairdnerii (steelhead trout) 121, 272
gairdnerii kamloops (rainbow trout) 121, 272
gairdnerii shasta (rainbow trout) 121, 272
lewisi (Yellowstone trout) 99, 136, 270, 274
salar (Atlantic salmon) 70, 263
selenis (Piute trout) 268
 Salmon 33; ill. 34
 Anadromous migration, 264; Artificial propagation, 30, 285; Commercial importance, 263, 285, 287, 289; "Homing instinct," 264, 267; Spawning habits, 103, 264, 267, 285, 287, 289, 291; Studies of scales to determine age, 101-102; ill. 97

	Page		Page
Salmon <i>Continued</i>		Seattle, Washington, Chinook salmon caught near	ill. 253
Atlantic 28, 70, 101-102, 163, color plate	71	<i>Sebastes</i> (genus of rockfishes)	235
Blueback. See <i>Salmon, Red</i>		<i>myxinus</i> (black rockfish)	228
Chinook 288, color plate	284	<i>rosaceus</i> (red rockfish)	235
Chum 291, 293, color plate	290	<i>Scophthalmus</i> (Atlantic moonfish)	197
Coho. See <i>Salmon, Silver</i>		Senses and sense organs	103
Dog. See <i>Salmon, Chum</i>		Barbels 51, 104, 143, 263, 281; ill.	301, color plate 142
Humpback. See <i>Salmon, Pink</i>		Eyes 11, 12, 19, 42, 44, 222,	258
Kennebec 339		Hearing 19	
King. See <i>Salmon, Chinook</i>		Otoliths 44, 106,	244
Penobscot 339		Taste 19	
Pink 289; color plate	288	Sergeant major 148, 163; color plate	160
Red 279, 287, 289; color plate	286	<i>Seriola dorsalis</i> (yellowtail)	224
Silver 285; color plate	284	<i>dumerili</i> (amberjack)	205
Sockeye. See <i>Salmon, Red</i>		Sexes of fishes not readily distinguishable	102
White. See <i>Yellowtail</i>		Shad 28, 31, 57, 62, 241, 338; ill.	342; color plate 56
Salmon fishing contest: Elliott Bay, Seattle, Wash- ington 253		Artificial propagation 30	
"Salmon trout" (Dolly Varden and Yellowstone black- spotted trout) 293		Nutritious 60	
Salmonidae (salmon and trout family) 263, 270, 285,	293	Scarcity of 57	
<i>Salvelinus</i> (charms) 264		Hickory 16	
<i>fontinalis</i> (brook trout) 128, 130		Shad roe: Substitutes for 338	
<i>malma</i> (Dolly Varden trout) 293		Shagreen (shark skin) used as abrasive 257	
Sanborn, (Mrs.) Paul: Photograph of	ill. 174	Shale, Fossil fishes found in 244, 283, 349-355; ill. 350, 352, 353,	354
Sand dab 259; color plate	258	Shark River, Florida: Tarpon	ill. 328
Sand fleas 70		Shark	
Sand lance 51		Basking 219, 257	
"Sand perch" 339, 347		Black-tip 163	
Sandy Key, Florida 329		Brown 163	
Santa Catalina Island, California 230		Ground 161	
Tuna fishing 35		Leopard 257; color plate	256
<i>Sarda sarda</i> (bonito) 86		"Man-eater." See <i>Shark, White</i>	
Sardine, California 244; color plate	245	Sand 167	
Sardines		Thresher 212	
Canning 28		Whale 257	
Catch of: New Brunswick 60		White 256, 257	
Herring fry canned as 18, 28; ill.	35	Shark leather: Commercial importance 257	
<i>Sardinops caerulea</i> (California sardine) 244		Shark sucker 163; color plate	158
Sars, (Prof.) 40		Sharks 339; ill.	181
Sauger. See <i>Pike, Sand</i>		Prehistoric, 352; Primitive form, 161; Reproduc- tion 161, 163	
Sauries 246		Sheeps'-wool (commercial sponge) 325	
Sawfish 180		Sheephead 66, 68, 91, 337; color plate	90
Sayville, Long Island, Blue Point oysters come from 347		Importance as game fish 91	
Scales, Fish: Age determined by 30, 101-102, 244, 285; ill.	97	See also <i>Drum, Fresh-water</i>	
Scallops		Shellfish fisheries 29, 150	
Deep-sea 347		Shells of trunkfishes 150, 157	
Long Island 347		Shewlin, Thomas: Photograph of	ill. 174
Scavengers, Some fishes are 100		Shiner. See <i>Butterfish</i>	
Schmidt, (Dr.) J. 145		Shore fishes: Pacific Coast 220	
Schools, Fish feed in 179		Shoshone Falls, Idaho 355	
Schroeder, William C. 68		Shrewsbury (river), New Jersey 327	
Schutt, L. P. 327		Shrimp	
Sciaenidae (croaker family) 93, 106, 244		Black. See <i>Shrimp, Black-tailed</i>	
<i>Scientific Monthly</i> 261		Black-tailed 255, 257; color plate	254
Scofield, N. B. 230		Deep-water. See <i>Shrimp, Black-tailed</i>	
<i>Scomber scombrus</i> (northern mackerel) 53, 86		Ghost 239; color plate	238
Scomberesocidae (sauries) 246		Shrimps 31, 255, 341; ill.	27
<i>Scomberomorus maculatus</i> (Spanish mackerel) 199		"Silver King." See <i>Tarpon</i>	
<i>regalis</i> (kingfish) 199		Singing fish 220	
Scombridae (mackerel family) 93, 224		<i>Sirocco</i> (yacht) 190	
<i>Scorpaenichthys marmoratus</i> (marbled sculpin) 241		Skate 337	
Scorpaenidae (rockfishes and scorpion fishes) 228, 235		"Skate" (fishing line): Pacific halibut fisheries 222	
Sculpin		Skate "wings" sold for food 257	
Giant 241		Skatewings 347	
Marbled 241; color plate	240	Skipjack. See <i>Butterfish</i>	
Sculpin roe poisonous 222		"Skittering" (method of angling) 139, 141	
Sculpins 220		"Sliders" (fresh-water turtles) 99	
Scup 31, 68, 337; color plate	69	Slippery dicks 301	
Sea basses 148, 149		Smelt 77; color plate	76
Sea beads 322		Columbia river 281	
Sea-beans 171		Green 77	
"Sea bush" color plates 312, 316		Long-finned 281	
Sea chrysanthemums color plate	319	Silver. See <i>Smelt, Surf</i>	
"Sea Creatures of Our Atlantic Shores" 296		Surf 220, 222	
Sea cucumbers. See <i>Holothurians</i>		Smith, Richard T. 259	
Sea-drums 165		Smithsonian Institution, Washington, D. C. 25, 31	
Sea fans 215, 299		Smokehouse, Lockeport, Nova Scotia: Herring 18	
Sea grape (plant) 308		Smelts (young salmon) 290	
Sea grapes (ascidians) color plate	322	Snail, Sand collar color plate	309
Sea horse 149, 255; color plate	156	Snails 307	
Sea minks. See <i>Kingfish</i>		Snake Bight, Florida 329	
Sea peach color plate	318	Snapper	
Sea pork color plate	322	Dog 183	
Sea potato color plate	317	Gray 152, ill.	146
"Sea serpents" 219		Red 31, 152	
"Sea squirt" color plate	317	Snapper family 189, 194	
Sea urchins 215, 302; color plate	313	Snappers 151-152; ill.	345
Green color plate	319	Snout of marlin 182, 185	
Sea vases color plate	322	<i>Sofia</i> (swordfish) 74	
Seagulls 179		Soldado. See <i>Squirrel fish</i>	
Sears, (Mrs.) Henry: Photograph of	ill. 174	Sole: Fish substituted for 337, 343, 347	
		Soledad Pass, California: Fossil fishes 267	

- | | Page | | Page |
|--|--|---|--|
| Trout | 103, 264, ill. 99, 269 | Viosca, Percy Jr | 115 |
| Bastard | 89 | Vipera, Captain | 100 |
| Brook | 121, 128, 130, 293, 337, ill. 123, color plate 129 | Virginia spot. See <i>Spot</i> | |
| Brown | 103; ill. 266 | Viviparous fishes | 11, 180, 181, 228, 235, 255 |
| Coastal cutthroat | 270, color plate 271 | Vogt, W. C. | ill. 124 |
| Dolly Varden | 276, 293, color plate 292 | | |
| European | 100-101 | W | |
| Gray. See <i>Squeague, Gray</i> | | Wahoo | 189, ill. 185 |
| Lake | 119, color plate 118 | Walton, Izaak | 70, 96-97, 209 |
| Mackinaw. See <i>Trout, Lake</i> | | Warren, New Hampshire | Rainbow trout in hatchery, ill. 127 |
| Montana Blackspotted. See <i>Trout, Yellowstone</i> | | Warsaws | 337 |
| Piute | 268; color plate 269 | Washington, University of | 219, 239 |
| Rainbow | 103, 121, 126, 128, 272, 276, 337, ill. 127; color plates 120, 273 | Washington Monument, Washington, D. C. | 339 |
| Rock. See <i>Greenling, Kelp</i> | | Washington mud minnow | 267 |
| Sea | 338, 347 | Water glass | ill. 294 |
| See also <i>Greenling, Kelp</i> , and <i>Squeague Gray</i> | | "Water-hardening" of fish eggs | 291 |
| Silver. See <i>Trout, Bastard</i> and <i>Redfish</i> | | Weakfish. See <i>Squeague, Gray</i> | |
| South Fork golden | 268; color plate 269 | Weymouth, (Dr.) F. W. | 259 |
| Speckled. See <i>Trout, Brook</i> | | Whales | 212, 257 |
| Spotted. See <i>Squeague, Spotted</i> | | Killer | 75; ill. 214 |
| Steelhead | 121, 272 | Sperm | 75 |
| "Steelhead cutthroat" | 270, 271 | Whale | |
| Yellowstone | 99, 136, 270, 274; color plate 275 | Channeled | color plate 309 |
| Trumpet-fishes | 165 | Dog | 299; color plate 318 |
| Trunkfish | | Furbelowed | 299; color plate 318 |
| Buffalo | color plate 157 | White angel. See <i>Spade fish</i> | |
| Smooth. See <i>Cuskold</i> | | Whitebait | 62 |
| Trunkfishes | 150, 157; ill. 301 | Whitefish | 101, 117, 132, 270, 337; ill. 137; color plate 116 |
| <i>Tuba bullata</i> (tuba sponge) | 308 | Commercial importance | 116 |
| Tuna | 16, 33, 35-36-37; ill. 21, 165, 218 | Studies of scales to determine age | 102 |
| School of feeding on sardines | ill. 162 | Whitefish roe substituted for caviar | 338 |
| Allison | 185-186 | Whiting | 31, 51, 347; color plate 50 |
| Bluefin | 55, 182, 185; color plate 54 | King | 39, 93, 347; color plate 92 |
| Tuna Club, Catalina Island: California | 224 | Shore. See <i>Whiting, King</i> | |
| Tunicates | 26 | Silver. See <i>Whiting, King</i> | |
| Snowy | color plate 322 | Surf. See <i>Whiting, King</i> | |
| Tunney, Gene: Photograph of | ill. 136 | Whitney, (mount), California | 268 |
| Tunny. See <i>Tuna</i> | | <i>Wide World Magazine</i> | 261 |
| Turtle | | Wilby, G. V. | 237 |
| Green | 192; color plate 208 | Williams, Stephen R.: Study of migrating eyes in fishes | 11 |
| Hawksbill. See <i>Turtle, Shell</i> | | Wilmington Falls, New York | ill. 88 |
| Shell | 173, 192; color plate 208 | Winchester, G. A. | 141 |
| Turtles, Prehistoric | 352 | Worms | |
| Tutuila Island, Pacific Ocean | 255 | Beakthrowers | color plate 320 |
| Typhinae | 255 | Clamworm | color plate 320 |
| | | Fan | color plate 320 |
| U | | Ornate | color plate 320 |
| United States | | Red-plumed | color plate 320 |
| Per capita yearly consumption of fish | 48 | Sand builder | color plate 321 |
| Total fish crop per year | 48 | Scale | color plate 320 |
| U. S. Bureau of Fisheries, Washington, D. C. | 9, 11, 16, 19, 25, 53-54, 46, 48, 55, 68, 77, 79, 96, 98, 274, 339 | Sea | ill. 302 |
| Efforts to preserve salmon and trout | 263 | Sea dianthus | color plates 321, 322 |
| U. S. Bureau of Fisheries Laboratory, Seattle | 239 | Wrasse | 163, 164 |
| U. S. Coast and Geodetic Survey | 223 | | |
| U. S. Fish Commission | 57 | X | |
| U. S. National Museum, Washington, D. C. | 248, 261, 351 | <i>Xiphias gladius</i> (swordfish) | 75 |
| U. S. Supreme Court: Decision on California shrimp fisheries | 230 | | |
| University of Washington School of Fisheries | 293 | Y | |
| <i>Urophycis chuss</i> (squirrel hake) | 51 | Yachats, Oregon, Surf fishing near | ill. 232 |
| <i>floridanus</i> (hake) | 51 | Yaquina Bay, Oregon | 219 |
| <i>tenuis</i> (white hake) | 51 | Yellow jack. See <i>Runner</i> | |
| | | Yellow tail | 152, 180; ill. 301; color plate 159 |
| V | | Yellowstone Lake, Wyoming | ill. 136 |
| <i>Verella</i> (floating colony) | 296 | Yellowstone National Park, Wyoming: Yellowstone trout caught in | 274 |
| Velvet (commercial sponge) | 325 | Yellowtail | 224, 337; color plate 225 |
| Venus's-girdle (ctenophore) | 299; color plate 311 | Yolk sac: Fish fry | 30, 66, 70, 93 |
| Viajaca (fish) | 329 | | |
| Vincent (cape), Ontario | 136 | Z | |
| | | <i>Zwaard-fis</i> (swordfish) | 74 |

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